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PERMANENT WAY.

REPORT OF THE STATE ENGINEER OF NEW YORK. PREPARED BY S. H. SWEET, DEPUTY.

From the advance sheets of the Report of the State Engineer and Surveyor of New York, on Railroads.

The following timely, able and practical considerations form a part of the State Engineer and Surveyor's Report for 1868 upon Railroads. Official reports upon such subjects are often valuable in their details, but it is not often that a government engineer reads a sound, practical lesson to our railway managers and railmakers. Mr. Sweet obviously understands the mistakes that have been made and the ends that should be sought in both these departments, and he does not hesitate to characterize them in plain language. We copy, on this occasion, his remarks on Road-bed, Sleepers, Joints and Iron Rails. In a future number we shall quote the report on the subject of Steel and Steel-headed Rails.

Increasing Demand for Permanence of Way.—The statistics of European, as well as of American railways, clearly indicate that any notable economy of working and maintenance must be accomplished chiefly through the improvement of railway *tracks*. The renewal of rails is the largest item in the cost of maintaining a railway, and the modern system of running heavy trains by much heavier and longer engines, is throwing more work upon the rails every year. The increased *articulation* of locomotives, so as to relieve the lateral strains upon the road and the individual weights upon the wheels, though promising well, is yet experimental. When fully worked out, it will also lead to a still greater loading of trains, for in the other departments of working a railway, economy lies in the greatest possible concentration of power, attendance and labor. So that, however running gear and steam machinery may be improved, the permanent way of trunk lines, at least, always will be, and probably should be, worked to its full capacity. In fact, the strength and durability of a given track is the feature that limits the amount, and hence the economy of the transportation that can be done upon it.

But there is another and more formidable destroyer of permanent way than weight, and that is speed. The running time of our passenger traffic, instead of being shortened as the distances to be reached were increased, has been lengthened, as compared with the speed of ten or fifteen years ago. Whatever risks and expenses rival lines may have adopted in other particulars, they have harmoniously abstained from running fast trains. *This* is a bid for patronage, which the most reckless manager has not dared to make. The public have tolerated this state of things longer than could have been expected. There is now a general and growing demand for fast trains. The time of one individual is worth more than it was when railways were introduced, and thousands of individuals travel now where dozens traveled then. In view of the opening of the Pacific railway, the development of the vast and growing States of the far west, and the steady tide of business and pleasure travel from these distant regions to our seaboard, the economy of fast trains is to be counted by days instead of minutes. To meet this require-

ment, the first and heaviest demand must be made upon the permanent way. The steam engine and the vehicle may be adapted to high speed with comparative ease and economy, but every rail, every joint and every sleeper, from the Atlantic to the Pacific, and between all the centers of population, must be maintained in a condition not only to bear fast trains safely and smoothly, but to endure the quadrupled strains and percussions due to a doubled speed.

Every increment of "work done" upon a railway, every increase in the weight, number or speed of the wheels, every economy of concentrating labor and power, brings an increased demand for endurance directly upon the permanent way. And, indirectly, the quality of the permanent way determines the economy of power of traction and of maintenance of engines and rolling stock.

In the construction, of new lines, a vast economy in earthworks and viaducts may be obtained by means of heavier grades and curves, but at the expense of increased wear and tear of permanent way.

The desirableness, if not the necessity, of increasing the durability of our railway tracks, even to meet present demands, is the truth of all others that our railway managers do not require to be told. The object of the foregoing remarks is to remind them that this necessity, instead of decreasing, must constantly and rapidly increase, as traffic grows and railways reach out into the wilderness.

DRAINAGE, BALLAST, ETC.—The improvement of the road-bed, by means of better drainage and ballasting, although of very great importance, presents no engineering difficulties. The practice and the economy are well settled, and it is simply a question of spending a shilling to save a pound.

SLEEPERS.—The preservation of sleepers by chemical processes, is always the subject of experiment on one or another of our railways. The practice, however, is not general in this country, because the mashing of the rail into the sleeper usually destroys it in advance of decay. In England, the bearings of the chairs used (with the double-headed rail) on every sleeper, are so extended, that the mechanical injury of the wood is quite small; prevention against decay — usually immersion in coal tar—is therefore generally practised. The insufficient bearing offered by sleepers to the rails, is thus, directly and indirectly, the cause of their rapid destruction. It is stated that placing the sleepers closer than, say two feet apart centers, would prevent the convenient tamping of the ballast. It is objected to the longitudinal sleeper, that the rail, lying parallel with the fiber of the wood, mashes into it more easily than into the cross sleeper. These objections to sufficient bearing, are not inherent in either system, but arise from improper construction. Thoroughly good ballast would not require continual tamping. It is even proposed by some of our most experienced engineers, to cover the ballast with a coating of coal tar and gravel, to absolutely exclude water, and thus to prevent not only decay, but washing, freezing, heaving, settling—all destroying elements but vibration and wear. In this case, the timber bearings under the rails should be almost continuous, to prevent wear both on the ballast and on the rail. The mashing of rails into timbers, either longitudinals or cross sleepers, is largely due to the want of stiffness in the rails themselves. The low ∩ rails on the Great Western of England, are the most notable examples of this kind of failure. If the iron wasted in the thick stem and pear head of our worst shaped rails, were put into the *height* of stem, their resistance to deflection would be doubled, this resistance being as the cube of the depth.

There is a growing conviction among engineers, that the longitudinal system will become standard. It offers twice to three times as much bearing for the rail as the cross sleeper system. The whole strength of a longitudinal is added to the strength of the rail, considered as a beam to carry the load. The strength of the cross sleeper in this direction is wholly wasted. The longitudinal is almost certain to prevent the displacement of a broken rail. This system has never been tried on a large scale, with a high, stiff rail. It requires better ballast and more thorough adjustment than the other system. Independent points of support, like the isolated ends of cross sleepers, that can be blocked up or let down at pleasure, without reference to the rest of the superstruction, are the indispensable accompaniment of bad ballasting and imperfect drainage. But they are unsuited to any system of homogeneous, continuous and *permanent* way.

Iron sleepers are coming into use in countries where timber is very costly and unsuitable, and are the subjects of various experiments in England. The great defect of all imperishable sleepers, whether stone

or iron, has been want of elasticity. An anvil under a rail, and especially under a joint, is almost worse than an insufficient support. The failure of stone blocks on the Lowell, Camden & Amboy and various English lines, is often quoted to prove that rails cannot be laid on a stable and durable foundation. This is a most serious mistake. An inch thickness of wood between a driving-wheel rim and a tyre, doubles the endurance of a wheel; a quarter of an inch of rubber confined in a suitable chair allows the laying of rails upon stone blocks, without extraordinary wear. A great range of elasticity, or a general giving-way of the road-bed are not required—only an imperceptible yielding to the minute, but incessant vibrations known as jarring, which would otherwise destroy the whole fabric. A pocket cut in a stone block or cast in an iron sleeper and filled with a cushion of wood or rubber would afford all the elasticity required.

Rail Joints.—The selection of joint fastenings for the ends of rails is somewhat dependent upon the weight of rail required and hence upon the traffic. After twenty years of competitive trial with every variety of fastening, the simple fish-joint—an iron splice on each side of the rail—has become standard in Europe and is gaining ground here. It is the lightest and strongest fastening that can be applied, when rails are high and properly shaped to receive it. The old difficulty of nuts jarring loose, has been overcome by the use of elastic washers. Fishing a pear-headed rail three or three and a half inches high, would be perfectly useless. For light rails, and for steel rails (to save weakening them by punching) and as an auxiliary to the fish-joint, the new Reeves' fastening—a tight clamp upon the contiguous flanges of two rails, is coming largely into use. The mere chair or seating for the ends of rails is no longer considered safe nor economical for lines of heavy traffic. Although there is room for farther experiment, it cannot be said that the demand for a good rail-joint has not been met.

Iron Rails.—Some of the early rails put down in this country on roads of considerable traffic, lasted over twenty years, most of this service having been under light vehicles, but upon indifferent road-beds. These rails finally *wore out*—they did not laminate to any great extent. We have the specifications by which these rails were made, and we know the quality of the material put into them. Good iron without any admixture of old rails, was welded under the hammer and then reheated and reworked until it was made fine grained and compact in the highest degree.

It is often asked why we do not get such rails now. The answer is that they are never called for. It does not appear from any accessible records, that such a pattern, or such a specification, or such a price, or such a service have been contemplated in any modern specification. The old patterns were very thin and elastic in the head. The pear-head was an abortive invention to work off bad iron. The old rails being low and sound, could bend without injury, but as this extreme deflection would keep modern heavy vehicles constantly traveling up hill, heavier rails have been specified; 60 and 65 lbs. instead of 40 and 45 lbs. to the yard, thus increasing the difficulty of manufacture and the stress on the material.

Better iron rails can be made now than were ever made before: first, because our knowledge of impurities, fluxes, processes, characteristics and requirements has been enlarged. More suitable and more uniform iron can be produced. Second, because forge and rolling-mill machinery is heavier and better than of old. Greater refinement and condensation and closer welds can be made by modern hammers and rolls.

But rails made from suitable iron, such as would be used for axles and forgings—rails rolled from hammer-welded and reheated piles—would cost nearly as much as steel rails. In fact, rails of ordinary iron with heads of puddled steel (which is a high wrought iron made from the best material) are sold at $115 per ton.

American railway managers, instead of offering anything like cost for good iron rails, have made themselves notorious by establishing as standard, a brand of rails known all over the world as "American rails," which are confessedly bought and sold as the poorest, weakest, most impure, least worked, least durable and cheapest rails that can be produced.* Although American made rails are usually better, and although the more enlightened managers willingly pay higher prices to home makers, yet the general tendency has been to reduce prices to the lowest possible point *irrespective of quality*.

No specification is made, no test institut-

* See report of A. S. Hewitt, U. S. Commissioner to the Paris Exposition.

Also see letter of Mr. C. P. Sandberg, to the "London Times," in "Engineering," Jan., 1869.

ed, no care taken, except to find the lowest bidder, and he may use all old rails, cut up and laid in the rail pile, without breaking down, reheating or admixture, if he can only make them stick together till they are delivered. This is what the rail maker is hired to do, and he does it openly, but under protest.

A leading railway president and reformer, Mr. Hinckley, of the Philadelphia, Wilmington & Baltimore railway, says:* "There is great fear on my part that railway companies will themselves tempt steel makers to send a poor article, by buying the cheapest—first cost only considered—as they did with the iron masters. It rests with railroad men to keep steel rails good by buying no poor ones."

In order to meet the demand for cheap rails, our iron masters have introduced a poison into our railroad iron, from the effects of which we shall very slowly recover. Under the pretence of making the heads of rails hard and durable, they have made them of a cold-short iron, impregnated with phosphorus. Now as it is notorious that rails go to pieces chiefly by lamination—by weakness of materials and welds. the hardness of the head is not much utilized. But the disease reaches its climax in the next generation of rails. The old rails are cut up, piled with raw iron and rolled into a new rail. The phosphorus is now distributed throughout the mass, contributing both to bad welds and to cold-shortness where strength is most required. One slab of good fibrous iron is indeed placed at the bottom of the pile to form the flange; but, to balance it, a layer of phosphorus is put on the head.

As long, therefore, as old rails are used promiscuously in the proportion of $\frac{1}{3}$ to $\frac{2}{3}$ with new iron, it is impossible to guarantee new rails against breaking and rapid lamination. When old rails are selected by the fracture, and rolled into bars before being piled; when the new iron is selected for its quality and not for its cheapness, and when the top slabs are welded by the hammer and then reheated and rolled, good rails may be made out of the materials at hand, but at a largely increased cost.

Inasmuch as railway companies are not always satisfied with the representations of rail makers, as to cost, quality, etc., a plan has been suggested whereby inaccuracies of this kind are not likely to occur. A specification of iron and manufacture is to be agreed upon and to be carried out under the inspection of the railway company's engineer. The actual cost as shown by the rolling mill books, together with a certain price (not a certain percentage—for obvious reasons) per ton for wear and tear and profit, to be the price of the rails. In this way it is not possible for the consumer to demand features for which he is unwilling to pay, nor for the maker to profit by working in poor materials.

There is a remarkable difference in the wear of iron rails on our different lines, and this difference is almost in exact proportion to their cost. When traffic is so light that good iron rails will last from seven to ten years, and when the money to buy a better material cannot be raised, as in case of many new lines, the question of better iron rails is of the greatest importance. But for lines of heavy traffic, like the New York Central, Erie and Hudson River, no iron rail, however made, can meet the demand. At something less than the cost of steel, an iron rail can be produced that will wear out instead of going to pieces in the welds; but it will be so much softer and less homogeneous than steel, that the latter will be as great an improvement upon good iron, as good iron is upon the bad iron now in use. The wear of steel *tyres* is three or four times greater than that of the best iron tyres. It would obviously be impossible to make an iron rail superior to a Lowmoor iron tyre.

(To be continued.)

* Letter of December 22, 1868, to Edward Austin, Esq., Boston. See "Van Nostrand's Engineering Magazine," for April, p. 367.

THE LATE ORDNANCE COMMITTEE.

For "Van Nostrand's Magazine."

The late Joint Committee on Ordnance of both Houses of Congress was a body of men intrusted with the powers of Congress, representing the people and States of the country sitting in inquest over the acts of other public servants, and charged with the duty of enlightening Congress and the people as to the honesty and efficiency to be found in an important branch of the public service. The report they submit purports to be the unbiased verdict of six able men of high intelligence, having at their disposal unlimited sources of information, and the advice of all the experts in the world. The subject they are to investigate is one of peculiar interest, for it is a branch of special

requirement upon the successful administration of which largely depends our military prestige, and, by consequence, the standing and respect we are entitled to among other civilized nations. It is to be fairly presumed the verdict of this inquisitorial body will carry with it great weight among those who look merely at its surface, and those who do so are the great mass of the American people, who keep themselves informed respecting the actions of Congress. The undercurrents are unfortunately hidden. The motives and the evidence are seldom seen. Since upon these turn the whole value and significance of such a document, and they being carefully kept out of sight, as far as practicable, the power for harm and the wreaking of private malice are boundless in the hands of such a committee; and, it may be added, the criminality of deliberate falsehood all the greater.

It was this same committee which, last year, brought in a damaging report against the Chief of Ordnance—Gen. A. B. Dyer—charging that officer with having availed himself of his high position for his own private advantage; of having received private emolument for furnishing ordnance stores of inferior quality when a better quality was being offered; of suppressing the records of the ordnance officer when called upon to furnish evidence, and other charges too numerous to mention. By implication they also assaulted the whole system of American ordnance, and the present constitution of our ordnance service. Under the circumstances, the Chief of Ordnance, who had not been permitted to appear by counsel before the committee, or even to know the drift and character of the investigation, instantly applied for a Court Martial, which was refused, but a Court of Inquiry afterwards granted, consisting of Gens. Thomas, Hancock, and Terry. This court is now near the close of its labors, which have been assiduous and almost unintermitted since last November. The counsel for the prosecution is Clifford Arrick, Esq., formerly an examiner in the Patent Office; subsequently the agent of a New York firm for the manufacture of a patent projectile (the Eureka), of which Arrick is nominally or really the patentee, and W. S. Kennedy, Esq. The counsel for the defence are David D. Field, Esq., of New York, Col. S. V. Benèt, and W. A. De Caindry. The investigation has been most exhaustive upon all the points brought up by the committee. The first volume (a formidable one), and advanced sheets of the second are before us, and we have read them with great interest.

The main points established by the evidence—established, in great part, by the testimony extorted from the prosecutors, beyond a shadow of question, are:

1st. The committee was chiefly constituted of members utterly hostile to the Army in general, and to the Ordnance Department in particular.

2d. The examination was conducted at the instigation of a ring of disappointed contractors, chief among whom were Clifford Arrick, Norman Wiard, and Horatio Ames, and who were allowed every facility and license for entering testimony.

3d. That all persons sympathizing with, or interested in the Ordnance Department, were carefully kept in ignorance of the specific objects of the investigation, and from a full knowledge of the testimony; copies being refused to Gen. Dyer, as well as counsel to represent him, in an examination where the plaintiffs were superabundantly represented.

4th. The mutilation of evidence, the suppression of important facts and interpolation of ideas never intended to be conveyed—done chiefly by this same Arrick, who was clerk!! to the committee, and intrusted with the task of *systematizing* and "boiling down" the evidence, as he expresses it.

5th. That Gen. Dyer has not been pecuniarily, or otherwise personally interested in any contract or official transaction, nor is there the remotest trace of evidence that he ever received any benefit from any official transaction, or suppressed any evidence.

6th. That the report abounds in assertions and criminations, which the evidence, garbled, distorted, and prejudiced as it is, does not warrant under the most unfavorable construction.

7th. The final report of the committee was framed, drawn up, and written entirely by Clifford Arrick, as he himself acknowledges.

The proof of the first point will be perfectly clear by mentioning the names Butler, Schenck, Logan, and Howard. Senators Drake and Cameron were on the committee, but were seldom in the committee room, and had no share in it beyond a silent assent.

The proof of the second is in the correspondence between Ames and Arrick, which was before the court, and contained the de-

tails of the conspiracy and reports of progress.

The proof of the third appears in the testimony of Mr. V. E. Smalley, a clerk of the committee, which is perfectly explicit, and in the correspondence between Senator Howard and Gen. Dyer.

Of the 4th, the following is a single specimen out of many; being in relation to an attempt to show that Dyer was the real patentee of the Absterdam projectile, and Absterdam only the ostensible patentee:

Q. to Absterdam by Arrick: "I desire to know whether, in answer to a question put to you before the Joint Committee, you did not say, 'In reality I am not the inventor of two shells, but I am the maker of two shells, known separately to the Ordnance Bureau?'" * * *

Answer. "I wish the court to allow me to state that that evidence of mine in this book is mutilated; that evidence is a forgery; that evidence is manipulated to read differently from what it ought to; other words have been substituted for the ones I used in my testimony. I repudiate it. I said, "In reality I am not ONLY the inventor of two shells, *as I have three patents for improvements in projectiles*, but I am the maker of two shells known separately to the Ordnance Bureau.'" * * *

Q. "When did you write that down in the manner you have just read?"

A. "This morning, sir"

Q. "Who suggested that to you?"

A. "I suggested it to myself before I came here to Washington, when I read the evidence in New York. I was so disgusted with it, I meant to have the matter known if I only had an opportunity. That is not the only specimen. If I were allowed to digest it, and if I had the time, it would make a different story, so far as my evidence is concerned." [Mr. Absterdam then points out three more instances of flagrant mutilation.]

The reports of officers upon the relative merits of the Eureka and other projectiles, upon which important matters were made to turn, and charges based, were shown to have been grossly perverted in the hands of the committee by the production of originals in evidence before the court.

With respect to the 5th point, it will suffice to say that the prosecution do not even attempt to show that Gen. Dyer ever received any benefit from official transactions, and as for the suppression of evidence, the charge was shown to be as cool a piece of deliberate falsehood as we ever heard of.

As to the 6th, we have not room to specify, but can promise the most absolute proof and satisfaction in referring the inquirer to the record of the court.

Arrick's own testimony is categorical respecting the seventh point.

It is to be regretted that the inquiries of the court cannot be extended also to the *recent* report of this committee. But the exposure of the animus of the first report may discredit also the second, and possibly a brief examination of the latter may serve to put it into its proper connection. It seems that Messrs. Arrick, Wiard and Ames, after their success in getting Gen. Dyer in limbo, proceeded to the next step, viz: a more sweeping and explicit indictment of the whole Ordnance Department, and a condemnation of its material. So far as the committee could help them, they succeeded here also. The third step—their abolition and a substitution of a regime of their own—a Board under control of civilians (*i. e.*, of Arrick and Wiard), has not yet been taken and is not likely to be.

I. The report (February 15th, 1869), begins by the astonishing statement that the increase of calibers necessitated by modern warfare has "developed a remarkable and puzzling fact, viz: that systems of fabrication which, with small calibers, gave good endurance, when applied to large guns, proved to be failures." The committee, it seems, wish to express their ignorance of the first ground rule of constructive mechanics, that with an increase of dimensions the strains increase in a higher ratio than the strength—a principle as applicable to guns as it is to girder bridges. Thus, other things being equal, the intensity of the force of the powder will bear a definite ratio to the length of the shot. This force, acting upon a long shot, has to overcome the inertia of a greater amount of metal per square inch of surface in the base of the shot than when acting against a short one. Since an increase of caliber involves an increase of length in the projectile, the intensity or amount per square inch of explosive force increases accordingly. *How "puzzling!"*

The report proceeds:

"Elaborate experiments, stretching over a period of years, have been carried on in Europe and America to solve this problem, and many new systems which in theory promised success have been successively tried and abandoned, nearly all of them succeeding in small guns but failing in large ones, and failing, too, in a manner which increased the complications of the problem—a gun frequently enduring over 2,000 rounds, while another, precisely similar, would explode after a few fires—while guns made of the strongest material seemed generally to prove the weakest when put to the test. No nation at present has guns of large caliber, the endurance of which can be estimated with any degree of certainty. This difficulty, serious enough with smooth-bore guns, is greatly increased in rifles, the 30-pounder being the largest rifled gun that has exhibited even

comparatively good endurance in this country, *while in Europe no more satisfactory result has been obtained.*"

According to their own showing then, although thousands of dollars have been expended in Europe on ordnance experiments where one has been expended here, and though Europe has machinery which this country will not have for many years to come, we are, after all, *not behind* any nation in the world in respect to ordnance. Speaking of "strongest materials" proving weakest, the committee, I presume, refer to wrought iron and steel—metals not used by the Ordnance Department, except the former for the 3-inch rifle. We thank the committee for this unintentional assent to our practice, which is the use of cast iron. Touching the remark upon the inequalities of endurance of similar guns, we are very curious to know upon what evidence this assertion is founded. Imperfections are as liable to creep into individual guns as into any other mechanical contrivance, in which case the cause of failure may be discerned by inspection. Lastly, the value of the assertion that no nation has a reliable system of heavy ordnance turns upon the word "reliable." If it means that no system has been devised by which we can warrant a long life to every gun fabricated on it, whatever the size, as a mathematical certainty, we assent. The committee might also have suggested, in the same connection, that we have no "reliable" steam boilers, no "reliable" ships, no "reliable" railways—in short, that the millenium has not come. There is no more reason why an infallible gun should be expected of the Ordnance Department than infallible wisdom from an ordnance committee. We have no objection to a comparison of fallibilities. We hope to show before we are done that if our guns are not absolute perfection, and do not preclude the possibility of improvement, they are decidedly superior, in respect both of power and durability, to those of any other system of ordnance in any nation of the world.

II. The report then proceeds to state that the idea that rupture is produced merely by the explosive force of the powder is an error, "as is shown by the fact that the pressure of powder has been found to be uniform, as it gives a uniform range to the projectile, and at times does not burst a gun made of weaker material than others which have burst when fired with like charges." This is mere ignorance on the part of the author of the report. The pressure has *not* been found to be uniform, or anything like it. It is subject to the widest variations, not only as between guns of different calibers (which is obvious enough on principle), but as between guns of the same caliber and pattern. Uniformity of range does not by any means warrant the inference of uniformity of pressure. Indeed, this pressure is regulated by the grain and quality of the powder, and the grain may be so selected that in the average results of an indefinite number of trials, all degrees of pressure may be obtained at will between widely separated maxima and minima limits, while the range remains constant. But in rifled guns there is another source of variation, even with identical charges, viz: the enormous friction of the shot against the bore, to which may be added the length of cartridge and the unequal times required for complete ignition. All practical artillerists, who are well acquainted with experimental firing, are familiar with these causes and know the existence of wide variations in the pressure, as indicated by the pressure gauge. The following citation from experiments made at West Point on a 100-pounder Parrott (see "Holley's Ordnance and Armor," pp. 478–481), illustrates the matter:

CHARGE 10 LBS. OF POWDER; ELEVATION 5 DEGREES; PROJECTILE 99½ LBS.

No.	Powder.	Range.	Pressure.
1	Dupont 7.....	2,078	38,000
2	Dupont 7.....	2,180	45,300
3	Hazard 7.....	2,251	80,000
4	Hazard 7..	2,308	86,000
5	Bennington 5.....	2,221	27,500
6	Hazard cake	2,370	114,000

CHARGE 10 LBS.; ELEVATION 15 DEGREES; PROJECTILE 100 LBS.

No.	Powder.	Range.	Pressure.
13	Dupont 7.....	4,830	32,630
15	Hazard 7.....	4,911	48,700
17	Dupont 7.....	4,796	60,350
18	Dupont 7.....	5,030	64,000
20	Hazard 7.....	4,735	99,002
21	Hazard 7.....	5,045	102,980

These two selections are but samples of what may be found in every experimental record with rifled guns. They show conclusively that range alone is no measure of the pressure. As the committee cite no

other "facts" to sustain their assertion we fairly infer that they have none to cite.

III. After mentioning the various European systems and pronouncing them failures, the report declares the Rodman guns failures with the rest, and in proof quotes the report of the Chief of Ordnance of the Navy, who says:

"Opinions differ quite as widely in regard to the preferable mode of developing ordnance power, whether it shall be by smooth or rifled bores, by loading at breech or at muzzle, made from iron, cast or wrought, or from steel, solid or in connected parts. The relation of mass to velocity is also unsettled. In fact the question involves the necessity of going back to fundamental principles, and starting thence by well conducted experiments."

In other words, the statement of the Chief of Ordnance of the Navy, that "opinions differ as to the best mode of developing ordnance power," is proof that the Rodman guns cannot do what is expected of them. Really Jack Bunsby's logic is getting to be very commonplace.

IV. The reader will, therefore, appreciate the force of the remarks which follow this profound criticism of the expert committee:

"It, therefore, appears that, notwithstanding a long series of experiments extending over a long period of years, and the practical experience of our recent war, the ordnance officers of the government have not yet determined upon even the fundamental principles of their art, and possess no positive knowledge of the problem they have so long sought to solve. Mechanics is an exact science, and ignorance of that branch of it involved in the construction of guns would seem to show either want of knowledge of its principles, failure to understand their application, or superficiality of investigation, surprising in men whose minds have been from boyhood trained in the direction of a specialty."

These remarks are highly edifying, coming as they do from a committee, who begin their report by confessing ignorance of causes of failure in large guns as distinct from small ones,—assert that rupture is not due to the expansive force of powder alone,—that range is a measure of the pressure, and that the Rodman guns are failures because the Chief of Ordnance of the Navy says "opinions differ as to the best methods of developing ordnance power!"

In support of the assertion that each system of guns introduced has failed in practice, General Gilmore is represented as reporting that while only twenty-two large guns were mounted at Morris' Island at one time, fifty in all burst during the siege. This is not true. That report states that twenty-four burst, and this number includes a 30-pdr. which had been fired 4,606 rounds at a high elevation,—the most remarkable test, doubtless, on record, of any gun,—and several 100-pdrs. which had been fired more than one thousand rounds—an ample endurance for any rifle of that caliber. We shall speak of the Parrott guns further on.

The statement that Admiral Porter declared that all the Parrott guns used in his fleet to bombard Fort Fisher had burst is, we believe, literal; but the gallant Admiral, as the committee might have known, and probably did know, officially retracted this statement, and paid a high tribute to them on a subsequent occasion. However that may be, how do the committee sustain the charge of failure upon *all* systems when they have only attempted to quote the record of the Parrott system?

V. The next step is an attempt to show that the rupture of guns is due to molecular tension, caused by the heat of rapid firing, which, they say, assists the explosive force of the powder. Here, gentlemen, readers of the "ECLECTIC," is the "cat in the meal." To nine-tenths of you probably this startling hypothesis is no stranger. The pertinacity and self-assurance with which it has been urged by its author, has not allowed many people to remain in ignorance of it. After years of untiring solicitation, of persecution of every variety of government official; in spite of the reticence, or patient refutation, or ridicule, or snubbing, according to the temperament of individuals, which he had always encountered, he has persisted in urging it, and has at last found two advocates. One is Mr. Benj. F. Butler, and the other the editor of "The Tribune." We congratulate Mr. Norman Wiard. He has hit upon the persons of all others best qualified to champion this new revelation of his, which is to overturn all the systems of warfare now in vogue throughout the world. Surely the brilliant projector of the Dutch Gap canal, of the Fort Fisher powder boat, and the advocate of Col. Serrell's flying machine, is, of all men, the one best qualified for, and congenial to the task of convincing the world of Mr. Wiard's heat theory. We regret it should ever be necessary to speak seriously of such a matter. But it is useless to deny that Mr. Norman Wiard, the laughing-stock of every expert and engineer who has heard his name (and most of them have), is one thing, and Norman Wiard, wielding the thunder of a great Joint Congressional Committee, is another. We

decline to enter into any discussion of his foolish hypothesis, but we are forced to admit or deny the statements the committee have published for him.

(1.) It is stated that the conditions of rapid firing, which often occur in service, do not appear to have been realized in experimental firing, and therefore the destructive effects of heat have escaped the notice of experimenters. This is untrue. In 1863, comparative trials of banded and unbanded guns were made by direction of the Ordnance Department, and the effect of rapidity of firing was one of the specially designated objects of the investigation. These guns were, therefore, fired more rapidly than has ever been practicable in action, ranging from 93 to 140 rounds in two hours, and nothing whatever was developed to show that heating rendered them liable to burst. In the report of the siege of Charleston, General Turner states that after his officers and men had become experienced, the machinery of the carriages working smoothly, the 100-pounder could be fired once in 5 minutes, the 8-inch rifle once in 7 or 8 minutes, and the 10-inch rifle not oftener than once in 10 minutes. Eight rounds per hour is rapid firing for sea-coast guns. In experimental practice, the 100-pounder has been fired 20 rounds in 2 hours; the 8-inch rifle, 24 rounds in 2 hours 20 minutes; the 10-inch, 25 rounds in 2 hours 20 minutes. After the disaster at Fort Fisher, three 100-pounder rifles used in that action were fired 1,000 rounds each by direction of the Naval Investigating Committee, with a view of ascertaining, if possible, the cause of the bursting of the guns in that action. These guns all stood the test, and were fired during a large portion of the trial with greater rapidity than could possibly have been obtained in action, because no time was lost in sighting. Rapidity of firing has often been the subject of experiment where guns have been put to extreme proof.

(2.) The committee speak of the effects of the cooling of red-hot wrought-iron, of the strains inaugurated in the cooling of molten iron, &c., &c. As we see no connection between these hackneyed facts and the behavior of guns under fire, we omit to notice them further.

VI. The spontaneous rupture of guns is alluded to. This occurs sometimes in very large castings where certain grades of iron are used. So far as guns are concerned, it is liable to occur under bad management or carelessness whether the gun is cast solid or hollow. But every iron founder is well aware that there are some grades of iron too high for guns. It is not that which gives the highest tensile strength which is best suited for gun metal. The requisite material must have also a high degree or modulus of elasticity. The selection of the proper grades and qualities is a matter of extreme delicacy, and only the most perfect accuracy can insure the result. From the waste metal of every rough gun are taken test specimens, which are tested by the proper machinery as to their precise qualities, and any unusual deviation from the experimental standard subjects the gun from which it is taken to extra proof, or possibly even to rejection without trial. But it is satisfactory to know that such deviations seldom occur. When they do occur, it is not to be wondered at that the disturbance of the relations of molecular forces should manifest itself in spontaneous rupture. If the committee will obtain the passage of a law of Congress so altering the atomic constitution of elementary matter that it shall not deviate from standard behavior, and agree to enforce it, the Ordnance Department will no doubt consent to adopt the metal thus provided.

VII. We now come to the culminating point of the report:

"The fact that the ordnance officers of the Government find it necessary, at this late day, to return to the rudiments of their art, * * * shows a defect in the organizations of the Ordnance Departments calling for a remedy. The difficulty appears to have been two-fold; first, the ordnance officers, knowing their positions secure to them for life, have not felt the incentive to exertion and improvement which stimulates men not in the Government employ, and they have become attached to routine and to the traditions of their corps, jealous of innovation and new ideas, and slow to adopt improvements. An illustration of this is found in the fact, that the late war was fought with muzzle-loading guns (with the exception of carbines for cavalry), although a variety of excellent breech-loaders were urged upon the attention of the Government constantly, and the honor was reserved for Prussia, with a weapon inferior to many American inventions, to demonstrate the immeasurable superiority of breech-loading guns."

The charge of undue conservatism we shall not notice, further than to say, it is quite true with respect to the "improvements" urged by Mr. Wiard. That conservatism still exists, and we venture to prophesy that it will continue to exist when the humble writer of this notice gets to be Chief of Ordnance, at some dim distance in the future.

The "illustration" contains the same amount of falsification as many others. Primarily, the report speaks of the substitution of breech for muzzle loaders, as if it were a matter for instantaneous decision, involving no grave responsibilities. In the year 1860 no nation, and it is probably safe to say few individuals, thought of the general use of breech-loaders for infantry. Early in the war quite a number of infantry regiments were armed with the best breech-loaders known, and after a trial the advantages failed to appear. The first good breech or "magazine" loader offered was the Spencer. Numerous regiments were armed with it in the year 1864, perhaps earlier, and its merits in the hands of experienced troops were found to be decided. Every Spencer that could be obtained was taken by the Department for arming the cavalry, where its advantages were much more conspicuous than in the infantry. But the whole system of breech-loaders was so hedged in by patent rights, and these rights so powerfully backed up by political influence, that a general armament of the troops with these weapons was out of the question. Still the necessity for breech-loaders and their ultimate adoption was fully recognized by the Ordnance Department, and in 1865, the end of the war being felt to be near, vigorous steps were instantly taken for their supply, freed as much as possible from the insuperable clog of patent rights. The result has been the adoption of a breech-loader which the Department claims to be superior, by many degrees, to any in the world, and unhampered by the claims of patentees. Looking back with convictions now universally entertained, it is easy to ask, why were not these muskets adopted at the outset? *Going* back and looking forward we may reply, because no living man can predict any advantage for them. There was just one course to be followed in the premises — to select the most promising breech-loader, put it into the hands of the best regiments, and abide by the result. And this is precisely what was done. So far from Prussia setting us the example, Prussia had the benefit of our experience. Was anything heard in Europe before Kœniggratz of breech-loaders? Before that great day they were known and recognized here.

The report continues:

"In the second place, these officers, educated to a specialty and proud of their positions, come to look upon themselves as possessing all the knowledge extant upon the subject of ordnance, and regard citizen inventors and mechanics who offer improvements in arms, as ignorant and designing persons and pretentious innovators, who have no claim to consideration. Instead of encouraging the inventive talent of the country, these officers seem to have constantly discouraged it, and many complaints of improper and oppressive treatment have been laid before the Committee by persons who have sought to draw the attention of the proper authorities to what were supposed to be vital principles connected with their art."

It will be observed that Mr. Wiard speaks from bitter experience, and we could name others who probably have similar complaints to make.

"Another difficulty that has retarded progress in the science of ordnance has been the fact that prominent officers have been inventors of arms, and have possessed sufficient influence to secure the adoption and retention in service of their inventions, frequently without regard to the question of real merit, and to the prejudice of other and better devices brought forward by citizens or developed in other countries."

We are familiar with nearly every article used in the ordnance service—certainly with all important articles. A quarterly return of ordnance stores from some of our arsenals has been known to embrace some 12,000 to 13,000 different names of articles. We have spent some time in looking over the list also. As the result of our examination, we are unable to find any article upon which any ordnance officer is interested pecuniarily, in any way, by patent or royalty, directly or indirectly, unless, indeed, in some small item, unaccounted for, which will be stopped against the accounting officer's pay, when the Auditor gets hold of the vouchers. Gen. Rodman *did* have a patent on his method of casting guns, which he sold for a royalty to Chas. Knap, of Pittsburg, in 1847. The patent expired in 1861, was renewed for seven years, expiring again by limitation in 1868, and has not, I believe, been since renewed. As long ago as 1861, a hue and cry was raised against the Rodman patent, and when the petition for renewal was brought before Congress, a committee of investigation was appointed, consisting of Hons. Robert Dale Owen and Joseph Holt. The result was that Gen. Rodman's right to the patent was fully sustained and the renewal granted. We have known of a few instances where patents for ordnance stores have been taken out by ordnance officers, but the articles were not adopted by the Ordnance Board. The sentiment and practice of the officers of the corps is against patenting any improvement, excepting where the inventor has been put to great private expense for its

perfection, though *the right* to do so is maintained.

VIII. We now come to some statements of "fact" which, with much falsehood, have a measure of truth in them, though, by their arrangement and juxtaposition, they are made to yield inferences as false as any others, showing that, although figures do not lie, men will sometimes lie tremendously about figures.

"Great diversity exists in the two branches of the service, respecting the arms adopted and the manner of proving, mounting and using the same. The calibers, models, chambers and ammunition of the navy guns are entirely unlike those in use in the army. For example, the navy 12-pounder boat howitzer has a caliber of 3.4 inches, while the army 12-pounder guns are of the calibers of 3, 3.2, 3.67 and 3.8 inches."

There is but one army 12-pounder now in service, and that is 4.62-inch caliber. Of the guns referred to, the only ones having the designated calibers are the 3-inch rifle, which, it is true, fires a shot weighing somewhere near 12 lb.—*i. e.*, $9\frac{1}{2}$ to $11\frac{1}{2}$ lb., and the 3.67-inch or 20-pounder Parrott. Surely no human being ever before thought of calling these guns 12-pounders. The 20-pounder Parrotts were seldom used except as siege guns, though they were not uncommon in the navy. There is a discarded "12-pounder," that is Mr. Wiard's own, though he does not mention it. Specimens can be seen at our arsenals, put up among the "nondescripts" to illustrate the freaks of inventive genius.

"The models of the two guns are entirely different, so that neither could be used on the carriage of the other. The system of sighting is also different. A gunner in one arm of the service, without special instruction, could not use a gun belonging to the other, one being graduated to seconds of time of the flight of the shot, the other to degrees of elevation."

We would also add for the benefit of the uninformed, that the navy guns are also unprovided with horses, and the sailors are without picks or shovels, and even caissons and battery wagons are wanting in the naval armament. Seriously—if it is possible to be serious—what do the committee mean by "using either gun on the carriage of the other." What kind of service, and on what element do boat-howitzers perform, or are field guns used? What does Jack want of a pendulum-hausse when sighting his gun among the waves, or a soldier of a time-scale on land?

"It is impossible to use navy ammunition in an army gun, or army ammunition in a naval gun."

That being the case we should by all means advise the navy to use their own ammunition exclusively, and we tender the same advice gratis to the army. Yet it is freely acknowledged by ordnance officers that the advantage of a uniform system *in the higher calibers* is a fair subject for discussion, to say the least, though the disastrous consequences of a lack of it is the veriest bugbear. Not pretending at all to "speak by the card" in this matter, I yet venture the surmise that army ordnance officers are more than willing: I know nothing about the navy opinion. The 20 and 15-inch guns are nearly conformable already.

IX. In presenting their conclusions the committee say that

(1.) "No more heavy guns should be purchased" at present.

(2.) "The Rodman system, while partially successful in smooth bores and small calibers, has so far failed in rifles of larger caliber as to show it to be unworthy of further confidence. * * * The principle of initial tension, which is the basis of the Rodman system, appears to be of doubtful utility, especially for rifled guns. This tension, it is admitted, gradually disappears with age, and is finally entirely lost."

We are curious to know, if the Rodman smooth bores are "partially" successful, what a complete success would be. We have before us a list of cannon, "burst or otherwise failures, in the national service" since 1860, published in the "Tribune" of April 5th, as we have reason to believe by Mr. Wiard. It is "prepared from reports and evidence before the Joint Committee on Ordnance." The recapitulation states that twelve 15-inch Rodmans were disabled. Looking over the "full catalogue" we do not find any specified, and we are morally certain there have never been any such disasters to specify. The recapitulation contains six 15-inch Rodmans self-burst; the catalogue specifies only three. As these burst before they were inspected, and, therefore, were not in the national service, they do not belong to the list. One 13-inch Rodman is specified as bursting at the 738th fire—a fair endurance for that caliber. Here, then, we have *one gun* out of the thousands built on the Rodman plan for smooth bores which has burst, and that after a fair endurance, and this upon the committee's own *ex parte* evidence. We hope we shall live to see a *perfectly* successful gun according to the idea of the committee.

The recapitulation specifies eleven 10-inch

and 12-inch rifles on the Rodman plan as disabled. The catalogue specifies one 8-inch (the first one) at 80 rounds, and one 8-inch at 1,047 rounds—a very fine endurance—and one 12-inch at 470 rounds. This last gun was burst by the breaking and wedging of the shot in the bore, the pressure gauge showing a force of 135,000 lbs.! at the final discharge. Two other 12-inch rifles are "reported injured," but their injuries have never been heard of at the ordnance office. Nothing has yet transpired to discredit the Rodman rifles. Indeed their prospects are most hopeful. But few experiments have been made with them, and they are counted only as experimental guns. A sudden stop was put to all trials at the instigation of the committee, and the appropriation asked for to continue the experiments refused. This is the whole evidence upon which the Rodman system is pronounced a failure.

(3.) "Guns cast solid in the manner practiced in the navy under the direction of Admiral Dahlgren, while exhibiting satisfactory endurance as smooth bores, with small charges and hollow projectiles, have not the requisite strength for rifles of large caliber. This mode of casting seems to be defective in principle, as the tensions inaugurated in cooling have a tendency to aid the powder in rupturing the gun."

The Dahlgren guns need no defence. The wry faces made at them cannot be construed as an assault, and the only reply which can be made is to point to the record of the IX and XI in smooth bores.

A word or two about the Parrott system. It is useless to assert that these guns have proved perfectly successful. That, however, has little to do with their relative merits. The whole world is challenged to produce a large caliber rifle which has on the whole sustained so good a test. The English Armstrongs and Whitworths have shown no such average endurance, nor have the steel guns of England and Prussia. They are the only rifled guns in this country whose merits are known, and their record has on the whole been very good. Every experienced artillerist who has dealt with the 6.4, and 8 inch rifles can recall some instances of failure, but his confidence in them has been justified thousands of times where it has been shaken once. The unusual number of failures at Morris Island is ascribed to peculiar local causes. The fine and ever-drifting sand was blown perpetually into the muzzles of these guns, and with the lubricant and residuum of the powder formed a scale in the bore, which had to be removed with a steel chisel. Most of the failures occurred at the sand battery where this difficulty was greatest, while those having a marsh in front experienced scarcely an accident. Another alleged cause was the explosion of shells in the gun, generally by concussion, a disaster frequently occurring and which there seems to be no known method of preventing altogether. This is probably the chief obstacle to be overcome in rifle guns of large caliber, viz: a projectile that will leave the gun without breaking. The pressure gauge reveals the terrible danger of such a mischief, running up the pressure to 130,000 and 150,000 lbs., which is sure destruction to any gun which ever has been or ever will be made.

In reviewing the various systems of gun-making, the committee seem to have adopted the exhaustive process of argument. No guns made in Europe are of any value; of the guns made in this country neither the Rodman hollow cast, the Dahlgren solid cast, nor the Parrott banded guns, can be trusted. Wrought iron and steel are utterly condemned, and having exhausted every known or conceivable device, *with one exception*, we are categorically drawn to that exception. There is one system having no likeness to any other, and which the committee have indirectly countenanced, viz: Mr. Norman Wiard's. The record of Mr. Wiard's gun designed to obviate the destructive effects of heat is as brief as Cæsar's epigram—one gun, *one round*, many pieces.

But we must bring this paper to a close by one more revelation. Though morally certain of it, we do not assert that Mr. Wiard wrote that report. But we do assert that if he had been called upon to write one he would have written one substantially identical. In the supplement to the report of the Committee on the Conduct of the War, Vol. II, 38th Congress, 2d session, Senate Mis. Doc. No. 47, is a communication from Norman Wiard containing the same misrepresentations, groans, croakings and abuse of ordnance officers as appear in the committee's report, and in the same phraseology. Wiard's testimony contains the substance of the report, indeed the report is merely Wiard's testimony sand-papered. As Arrick wrote the other, why should not Wiard write this one? Lastly, we have it from high authority that at the direction of Senator Howard both Gen. Rodman and Admiral Dahlgren sat each a whole day to be pumped by this man, who put the questions,

took down the answers, and probably "boiled down" the testimony as well as wrote the report.

As I have advanced no theories, but stated only matters of official record (except in one or two specified cases), the readers of the ECLECTIC will perhaps be able to form some notion of the unique character of this report. D.

STRENGTH OF SCREW SHAFTS.

A Paper "On the Calculation of the Stress in Propeller Shafts," read by W. J. Macquorn Rankine, C. E., LL. D., F. R. S., at the Institute of Naval Architects, March, 1869.

(1.) Through a long series of practical trials, extending over many years, it was ascertained by Lieutenant David Rankine (h. p. Rifle Brigade), and by the author of this paper, that the greatest stress which the wrought iron axles of very smooth-running railway carriages, traveling at speeds not exceeding twelve miles an hour, would safely bear, when made of the best materials and in the best way, was 9,000 lb. on the square inch (or about 6.3 kilos. on the sq. millimeter). Any defect in materials or workmanship, when exposed to that stress, was always found to cause the axle to give way in the end, though sometimes not until it had run for more than three years. The immediate breaking stress was not directly ascertained, but it is probable that the factor of safety was between five and six. A greater factor of safety, or, in other words, a smaller limit to the intensity of stress, is of course required when the motion is rougher than it was in those carriages.

(2.) According to the ordinary method of calculating the greatest stress in propeller shafts, the moment of the twisting action upon the shaft is alone taken into account; and when that method is applied to examples taken from actual steam vessels, results are obtained approaching very near to the limit already stated. For instance, 8,000 lb. to the square inch is a not uncommon value of the intensity of the stress in a propeller shaft, as calculated from the twisting action alone.

(3.) But the real intensity of the stress is greater still, for with the twisting action there is always combined more or less of a bending action, produced partly by the weight of the shaft and partly by its reaction when the vessel pitches and heaves with the waves. The object of the present paper is to give rules for calculating the total or resultant stress produced by the twisting and bending actions combined, and to illustrate them by an example.

(4.) TWISTING ACTION.—The *greatest twisting moment* is to be calculated from the indicated horses' power of the engines, as follows: Multiply the power by 33,000, in order to reduce it to foot-pounds per minute, and divide the product by 6.2832 times the number of revolutions of the shaft per min. The quotient will be the *mean twisting moment* in foot-pounds (for kilogrammeters the multiplier is 4,500 instead of 33,000). The *greatest twisting moment* is greater than the mean twisting moment in a ratio which may be estimated at about 1.6 for a single engine, 1.11 for a pair of engines with cranks at right angles, and 1.05 for three engines with cranks at equal angles.

When British measures are employed, the greatest twisting moment having been computed in foot-pounds, is to be multiplied by twelve to reduce it to inch-pounds.

To find the *greatest intensity of the stress produced by twisting*, multiply the greatest twisting moment by $\frac{16}{\pi}$ ($= 5.1$ nearly), and divide by the cube of the diameter of the shaft. In symbols, let M be the moment, d the diameter, and q the *twisting stress*, as it may be called. Then

$$q = \frac{5.1\,M}{d^3}. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

(5.) BENDING ACTION.—The greatest stress produced on the particles of a horizontal cylindrical shaft by the bending action of its own weight is equivalent to the weight of a column of iron whose height is a third proportional to the diameter and the span between the bearings.

In symbols, let l be the span between the bearings (in inches if British measures are used); d the diameter; w the heaviness of iron (= .278 lb. per cubic in., or 7,690 kil. per cubic meter); p the greatest *bending stress*, as it may be called. Then

$$p = \frac{w\,l^2}{d}. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The *reaction* of the shaft produced by vertical oscillations, as in pitching and heaving, bears the same proportion to its weight that half the extent of the oscillations bears to the length of a pendulum which keeps time with them. Let m be that proportion; then the bending stress is increased to

$$p = (1 + m)\,\frac{w\,l^2}{d}. \quad . \quad . \quad . \quad (3)$$

In a vessel that follows the vertical heaving of the waves the value of m is nearly the sine of the wave slope—say, 0.25 in extreme cases, and 0.125 in ordinary cases.

(6). RESULTANT STRESS.—The resultant stress due to the twisting stress q and the bending stress p combined, is found by a formula which has been demonstrated by writers on the internal equilibrium of elastic solids; that is to say,

$$s = \sqrt{\left(q^2 + \frac{p^2}{4}\right)} + \frac{p}{2}, \quad . \quad . \quad (4)$$

where s denotes the intensity of the resultant stress.

(7.) NUMERICAL EXAMPLE.—In the following example the results are not computed beyond four significant figures.

Indicated H. P.....	5,500
Multiply by.....	33,000
Divide by ..... 6.2832)	181,500,000 ft.-lb per min.
Revo. per min .....54)	28,890,000 quot'nt nearly.
Mean twisting moment .	535,000 foot-pounds.
For a pair of engines multiply by.....	1.11
Greatest twisting mom't	593,850 foot-pounds.
Multiply by.....	12
	7,126,200 inch-pounds.
Multiply by.....	5.1
Diameter, $16\frac{1}{4}$ in. .....)	
Diameter ^{3} .....4,492)	36,340,000 product.
Twisting stress, $q =$ ...	8,090 lb. on sq. in.
Span between bearings..	25 ft. = 300 in.
Divide by diameter	$16\frac{1}{2}$)90,000 square of span.
Third proportional.....	5,455 inches.
Multiply by weight of a cubic inch of iron ...	0.278 lb.
Bending stress by weight alone	1,516 lb. on sq. in.
× estimated value of 1 + m, say.....	$1\frac{1}{8}$
Bending stress by weight and reaction = p =..	1,704 lb. on sq. in.

Resultant Stress.

$$s = \sqrt{\left(q^2 + \frac{p^2}{4}\right)} + \frac{p}{2} = 8{,}987 \text{ lb. on}$$

the square inch, being practically equal to the greatest safe stress of 9,000 lb. on the sq. in., mentioned in sec. 1, as applicable to smoothly running railway axles at low speeds.

(8.) It seems very probable that if the method of calculation now described were applied to actual examples of propeller shafts, many instances would be found in which the resultant stress reaches, or even goes beyond, the utmost limits consistent with safety; and it is therefore laid before the Institution for their consideration, and for that of shipbuilders and marine engineers in general.

(9.) RULES FOR DESIGNING SHAFTS.—The conditions which the diameter of a shaft ought to fulfill are expressed by the following equation, derived from equation 4:

$$s^2 - s\,p - q^2 = 0; \quad . \quad . \quad . \quad (5)$$

in which, for s, is to be put a safe working value of the resultant stress (say 8,000 lb. on the sq. in., or 5.6 kilos. on the sq. millimeter), and for p and q, their values in terms of M, l, w, and d, as given by equations 2 and 1 respectively. The equation then becomes of the *sixth order*, and it is to be solved so as to find d. This can be done by approximation only; and a convenient method of approximation is as follows: Assume for q an approximate value q^1, somewhat less than that of s (say, $q^1 = 0.9\,s$). Then calculate an approximate value d^1 of the diameter from equation 1, viz.,

$$d^1 = \left(\frac{5.1\,M}{q^1}\right)^{\frac{1}{3}} \quad . \quad . \quad . \quad . \quad (6)$$

Then calculate for p an approximate value p^1 from equation 3, viz.,

$$p^1 = (1 + m)\,\frac{w\,l^2}{d^1}; \quad . \quad . \quad . \quad (7)$$

and from the approximate value of p^1 calculate a second approximate value of q as follows:

$$q^{11} = \sqrt{(s^2 - s\,p^1)}. \quad . \quad . \quad . \quad (8)$$

Should this agree with the first approximate value q^1, the approximate diameter d^1 will answer; and should there be a difference, a second approximation d^{11} to the required diameter is to be computed as follows;

$$d^{11} = d^1 \left(\frac{q^1}{q^{11}}\right)^{\frac{1}{3}}. \quad . \quad . \quad . \quad (9)$$

When, as is usually the case, the difference $q^1 - q^{11}$ is small compared with q^1, the following formula for the second approximation is sufficiently near the truth:

$$d^{11} = d^1 \left\{1 + \frac{q^1 - q^{11}}{3\,q^1}\right\} \quad . \quad (10)$$

A third approximation might be found by repeating the process, but the second approximation will in general be found accurate enough for practical purposes.

Should q^{11} prove to be greater than q^1, the correction in equation 10 becomes negative; that is, the second approximation to the diameter is less than the first.

(10.) EXAMPLE OF THE RULE.—$l = 300$ in. as before.

Twisting moment M =	7,126,200	in.-lb., as before.
Multiply by.....	5.1	
Divide by $q^1 = 7{,}200$)	36,340,000	product.
First approx., $d^{1\,2}$ =..	5,047	
" " d^1 =..	17.15	inches.
Divide by d^1 = ...17.15)	90,000 = l^2,	as before.
	5,248	third proportional.
Mult. by $(1+m)$ w =	.313	
First approx., p^1 =..	1,643	lb. on the sq. in.
Intended resultant stress, s = ...	8,000	
Multiply by $s - p^1$ =	6,357	
Second approx. $q^{11\,2}$ =	50,836,000	
" " q^{11} =	7,131	lb. on the sq. in.
First " q^1 =	7,200	
$q^1 - q^{11}$ =.....	— 69	

Second approximation to required diameter:

$$d^{11} = 17.15 \left\{ 1 \times \frac{69}{3 \times 7{,}200} \right\} = 17.21 \text{ in.}$$

ROLLING MILL GEARING.

The heaviest cog-wheels in the world—always excepting Mr. Isherwood's screw steamships—are to be found in iron rolling mills. Nothing at all resembling this gear is to be discovered in flour or cotton mills, or in any other situation on land where steam power is employed. Spur-wheels 18 ft. to 25 ft. in diameter, 24 in. wide on the face, and 8 in. or 9 in. pitch, are not uncommon; while pitches of 6 in. and widths of 18 in. and 20 in. may be met with in almost any little rolling mill we can enter. The quantity of gearing employed in driving an ordinary rail or forge train is even more remarkable than its dimensions. First, we have a tremendous spur-wheel on the engine shaft, working into a pinion on the fly-wheel shaft, which gears again into a spur-wheel, on the shaft of which is a square end to take the coupling-box and breaking-spindle to the rolls. We have in this arrangement three spur-wheels and six bearings, all of the largest and heaviest class; and this, be it observed, is rather a simple mill than otherwise. When a hammer, a shears and a second train have to be driven, we generally find as much gearing as would fill a good-sized modern dwelling-house, running at a high velocity, for the most part badly put to work, and therefore noisy and liable to accident. It is not too much to say, in fine, that at least one-half of the whole power developed is expended in keeping this gearing in motion; while its first cost represents one-half the capital invested in the plant of any iron mill.

It is worth while, under such circumstances, to consider whether gearing may or may not be dispensed with; and whether we can or cannot improve upon arrangements admittedly objectionable if tested by comparison with other mills. In dealing with the subject, we must first ascertain why gearing is used at all. This point is soon settled. The velocity at which ordinary trains run varies between 40 revolutions per minute for sheet mills and 100 revolutions per minute for bar or rail mills. Higher and lower velocities are met with, no doubt, but the two which we have named are those most usually adopted, and all that we shall say on this subject just now, will be sufficiently illustrated by cases afforded by those two speeds. Now the work to done in rolling iron is excessively variable, and it is therefore necessary to employ great fly-wheel power, in order to store up force at one time sufficient to carry the bar, rail or sheet through the rolls at another. Without going into mathematics, we may state here that the force afforded by any fly-wheel for overcoming the resistance offered to the rolls of a train varies as the square of the number of revolutions, the weights being the same. Thus, a fly running at 80 revolutions per minute would be practically four times as efficient as one similar in all respects and running at 40 revolutions. Therefore it has come to be looked on as an axiom by rolling mill engineers, that the fly-wheel cannot be run too fast. As a consequence, in old works we always find it put on a second-motion shaft, never on the engine shaft. In the endeavor to obtain high fly-wheel speed we find the first cause for the introduction of gearing in rolling mills.

The second reason lies in the fact that until a few years back, slow moving engines of great size were alone employed to drive sheet and rail trains. These engines had a long stroke, and ran at but eighteen or twenty revolutions per minute. This being too slow for any but blooming rolls, gearing became a necessity. The enormous dimensions usually imparted to rolling mill gearing is explained by the fact that it is exposed to many shocks and jerks which are peculiar to the work which it performs, and that for the most part it is roughly and cheaply made, and carelessly put together. We have, we believe, given in the foregoing paragraphs every valid reason which can be alleged in favor of the use of clumsy, heavy, costly gearing in rolling mills. It remains to be seen whether these reasons are or are not incontrovertible.

Taking the last phase of the question first, we may state that during the last few years better materials, better proportions, and superior workmanship have been introduced by many makers, such as Claridge, North & Co., and others, with a view to keep down the weight of mill gearing, and with much success, especially in Staffordshire; and it is beyond question that still more may be done in this direction. But it is quite in another way that we must look for radical improvement. We must begin at the fountain head, and instead of heavy, lumbering, slow working engines, resort to the use of machines making a fair number of revolutions without an excessive piston speed. A good deal has already been done in this direction, we are happy to say. At Woolwich arsenal the splendid bar mill is driven direct at some 60 revolutions per minute by a horizontal engine. In this case power is stored up in one of the finest fly-wheels in England, weighing 50 tons. The sheet train of the Warrington Wire Iron Co. is driven direct by an engine fitted with a 60-ton fly-wheel. These great weights are rendered necessary by the comparatively slow speed of the trains. When velocities of 100 revolutions are attained a 20-ton wheel will answer every purpose. As an illustration we may cite the Pendleton works, near Manchester, where a 16-in. rail mill is driven direct at 100 revolutions per minute, by a horizontal engine with a 26 in. cylinder and 4 ft. 6 in. stroke. This engine has been running constantly for the last fifteen years, with few or no repairs. The advantage of this system cannot be over-estimated. The cost of a great mass of heavy gearing is saved; the price of the engine is not nearly that of a larger and slower running machine; the chances of breakdowns are reduced to a minimum; and the expense of repairs, wear and tear, and lubrication is obviously very greatly diminished.

When, as in sheet mills, the rolls run too slowly to permit the engine to be coupled direct to them with advantage, the best plan will still be to use a small engine, running at some 70 or 80 revolutions per minute, and carrying on its shaft a spur-pinion gearing into a spur-wheel on a second-motion shaft driving the rolls direct; we thus retain a high velocity in the fly-wheel and a cheap engine, although some of the disadvantages connected with the use of gearing unavoidably remain.

The gearing at present usually employed in reversing mills consists of no fewer than five huge spur-wheels and pinions, besides the clutch-boxes. The entire arrangement is simply a barbarous relic of the past. Reversing mills should be driven by small, high-speed coupled engines, without fly-wheels, and fitted with a link motion. The first cost is not greater than that of the normal arrangement, while the waste of power and the chances of derangement are greatly reduced. Those who wish to realize what can be done in this direction, should see for themselves engines and mills designed by Mr. Ramsbottom for Crewe, and others manufactured by Messrs. Tennant, Walker & Co., of Leeds, for America.

The above is from the "Engineer." There are many mills in this country to which these criticisms apply. But the greater number of our *rail* mills have engines coupled directly to the trains—vertical engines, too, which take up the least room. And for work no heavier than rails our three high mill is a vast improvement on the reversing mill. Indeed, with proper lifting gear, it is probably better for the heaviest work, such as 15 in. beams. In some of the new English rail mills, two or even four trains are connected to a single engine by no end of cog-wheels.

We can copy the English practice with advantage in many cases; but in the matter of rail mills, our neighbors should study our practice, for instance at Reading, where they would see three 23 inch 3-high trains, driven each by its own direct vertical engine, at 60 to 80 revolutions; at Harrisburg, where a 40 in. by 60 in. direct vertical engine drives a 24 in. 3-high *steel* train, four rolls long, at 60 revolutions; and at Johnstown, where a similar engine, with a 60 ton fly-weel, drives, direct, a 21 in. puddle train five rolls long, and two squeezers.

THE BED OF THE ATLANTIC.—It has for some time been a question in the learned societies of England, as to the nature of a gelatinous substance formed at the bottom of the Atlantic, specimens of which have been brought up by sounding apparatus. Prof. Huxley has given it the name Bathybius. By some it is considered a gigantic Protozoön, which covers a vast area, miles in extent, forming a living mass over it. It would thus be an agglomeration of microscopic animalcules, probably possessing, like plants, the power of subsisting upon inorganic matter.

FAIRLIE'S LOCOMOTIVE CAR.

This is a long, eight-wheeled passenger car, resting at one end on an ordinary truck, and at the other on a locomotive truck. It is designed to run on rails laid upon common highways or upon ordinary railways. We compile the following description from "Engineering": The leading bogie, or truck, which has coupled wheels 4 ft. in diameter, is fitted with steam cylinders, and carries an upright steam boiler, and a platform for the driver and plenty of fuel space. The cylinders are inside, and are 8 in. in diameter, with 12 in. stroke. The boiler, which is of the "Field" class, stands on the platform of the truck midway between the two axles; the shell is continued downwards for about 16 in. below the fire-grate, so as to form an ashpit. The carrier frame is provided with a strap which completely encircles the base of the boiler, this strap being fitted with brass rubbing pieces on the inner side, so that the base of the boiler—which really forms a large bogie pin—can revolve freely within it to the extent of a quarter of a circle. At the hind end the carrier frame rests on the center of the trailing bogie, this latter being arranged so that it can swivel freely, and being provided with four ordinary carrying wheels, 2 ft. 6 in. in diameter. The carrier frame is made of four longitudinal frames, with cross frames and diagonals, the longitudinal frames being strengthened by truss rods, and the inside frames being connected for a portion of their length by plates at the top and bottom, so as to form a long shallow tank about 4 ft. wide by 12 in. deep. Under this arrangement the tank serves to materially stiffen the carrier frame, and at the same time the weight of the water is distributed over a considerable length of the latter.

The exhaust steam is led into the tank and made to traverse the whole length of the latter before being conducted to the chimney. In passing over the surface of the water a portion of the steam is, of course, condensed, whilst the remainder is discharged into the chimney without any objectionable noise. The chimney passes over the whole length of the carriage to the rear end; and we may here remark, by the way, that from experiments during the construction of some locomotives on the Northern Railway of France, having chimneys somewhat similarly arranged, it was proved that the action of the steam jet was fully as effective in chimneys so placed, as in those in the ordinary vertical position (!). Mr. Fairlie, however, places the chimneys of his steam carriages vertical, as usual in all cases, except when they are intended for working on a line laid along an ordinary road.

On the carrier platform is placed a carriage body, this latter being perfectly distinct from the carrier frame itself, and being merely a covering for the passengers, so that it can at any time be readily removed for repairs, and another bolted on in its stead. Instead, however, of removing the carriage body from the carrier frame, the latter may be readily detached from the leading bogie by simply taking out the bolts of the strap which embraces the base of the boiler, and the leading bogie—which may, in fact, be termed the engine—can then be attached to another carrier frame. When the leading bogie is detached, the front end of the carrier frame is supported on a pair of wheels which, by means of screws and a hand wheel with suitable gearing, can be lowered down so as to bear on the rails when desired. The ready means which are afforded for the detachment or separation of the various parts of Mr. Fairlie's steam carriage forms an important feature in his system, and one which will very greatly facilitate the execution of repairs. Thus, on a line where these carriages are employed, it will never be necessary to stop the running of an entire carriage to execute the repairs of one part, the replacement of a damaged engine, or carrier frame, by a duplicate kept in reserve, being the work of less than half an hour.

The construction of the carriage body is varied, by Mr. Fairlie, according to the nature of the traffic. For a light railway, constructed on a common road, and unprovided with regular stopping stations, (the carriage being intended to stop to pick up passengers like an ordinary omnibus,) the body is divided into two parts, for first-class (to seat 30) and second-class (to seat 50) respectively, the entrance to the former being in the rear of the vehicle, and that to the latter near the middle of the length of the carriage. A longitudinal gang-way runs the whole length. In both cases the steps are so arranged that passengers can readily mount into the vehicle from the road level. When the steam carriage is intended for running on a line provided with regular stations, Mr. Fairlie constructs the body with compartments and side doors in the ordinary

way. Thus arranged the carriage is well adapted for working passenger traffic on branch lines or for metropolitan traffic.

In the construction of the vehicle, steel is used instead of iron in all parts where its employment is advantageous, and care has been taken, by properly proportioning the various details, to avoid all unnecessary weight. The calculated weight of the whole vehicle, without passengers, but with fuel and water for a 40 mile run, is under fourteen tons; whilst with 80 passengers the weight would only be 20 tons, of which rather more than half would rest on the wheels of the steam bogie. It will thus be seen that the ratio of unpaying to paying load is, when the carriage is fully loaded, only about $2\frac{1}{3}$ to 1, while, as about 55 per cent of the total weight is available for adhesion, the carriage would be readily able to mount gradients of 1 in 16, if sufficient cylinder power was provided. In the case of a steam carriage, designed for running on gradients 1 in 35 or 1 in 40, the following are the calculations of adhesion, etc.

On an incline of 1 in 35, the resistance due to gravity would be 64 lb. per ton; and if we take the frictional and other resistances, exclusive of gravity, at 20 lb. per ton —an ample allowance—we shall have the total resistances as follows:

Gravity, 20 tons, at 64 lb. per ton,	= 1,280
Friction, etc., 20 "	= 400
Total, ...	1,680

Again, as about 55 per cent of the total weight rests on the wheels of the leading bogie, we should have

$$\frac{2240\times20\times55}{100}=24{,}640 \text{ lb.}$$

available for adhesion, an amount which, on an incline of 1 in 35, would be reduced to

$$24{,}640-\frac{24640}{35}=24{,}640-704=23{,}936$$

lb.; and dividing 1,680 lb., the total resistance, by this number, we get $\frac{1680}{23936}=\frac{1}{14\,8}$ as the co-efficient of adhesion required. In other words, so long as the adhesion exceeded, say $\frac{1}{14}$th of the weight on the driving wheels, the carriage would ascend an incline of 1 in 35.

On the other hand it will be found also, that the cylinder power is sufficient for taking the carriage up such an incline, the boiler being worked at a pressure of, say, 140 lb. per sq. in. Thus with 8 in. cylinders, 12 in. stroke, and 4 ft. wheels, the tractive force exerted for each pound of effective pressure on the pistons is 16 lb. To overcome the resistances amounting to 1,680 lb, as already calculated, the mean effective cylinder pressure would have to be 105 lb. per sq. in.

On a level road the total resistance of a steam carriage such as we are describing, running at a speed of 40 miles per hour, should not exceed 20 lb. per ton, or, taking the weight at 20 tons, 400 lb. in all. To overcome this resistance would require a mean effective pressure of 25 lb. per sq. in. on the pistons, and the power exerted would be $\frac{400\times5280\times40}{60\times33000}=42.6$ horse-power. On an incline of 1 in 100 the total resistance would be about $42\frac{1}{2}$ lb. per ton, or 850 lb. in all, corresponding to an effective pressure on the pistons of 53,125 lb. per sq. in., and to the development of 95.8, or say 96 horse-power at the same speed.

On a line with moderate gradients, say up to 1 in 60, and at speeds varying from 25 to 40 miles per hour, such a steam carriage as that we have described should be run with a consumption of about 6 lb. of coal per mile, and with a correspondingly small consumption of oil, tallow, etc. The expense for wages also would be very small, as the engine could be readily managed by one man, while the guard would have charge of the brake, and would be able to collect fares. Brake-blocks are to be applied to all the wheels; and the arrangement of brake-gear is such that the brakes can be applied either by the guard or driver independently.

Although the total wheel base of the carriage is 57 ft., yet the actual wheel base which has to be considered when estimating the capability of the vehicle for traversing curves, is that of each bogie, or 6 ft. only. With this base the carriage can be safely run round curves of two chains radius, at moderate speeds, while at a slow speed a curve of 35 ft. radius may be traversed. Thus, by placing circular curves of 35 or 40 feet radius at the terminal stations, the carriages can be run round, and the expense of turntables avoided.

We have hitherto spoken of Mr. Fairlie's steam carriage as running by itself only; but it will be evident from what we have said that it possesses ample power to draw, under ordinary circumstances, another carriage behind it. In the case of a railway

laid on a public road, such speeds as 40 miles per hour would, of course, never be attempted, a speed of twelve or fifteen miles per hour being more nearly the maximum; and in such instances the boiler would possess ample power to supply the cylinders with steam at the full pressure admitted for, say three-fourths the stroke, and ample tractive power would thus be afforded for drawing another carriage, or trucks loaded with goods. Altogether Mr. Fairlie's plans are exceedingly well considered, and we feel sure that at the present moment — when light railways are the subject of much attention—they will be regarded with great interest.

INDEPENDENT TUBULAR BOILERS.

From the "Practical Mechanic's Journal."

The Seguin tube boiler applied to the early locomotive by the Stephenson's, and proved capable of such rapid and efficient generation of steam, gave almost at once an impulse to the use of tubular boilers of one sort or other for land and fixed engine use, which, however, has not been followed out, nor has progressed as steadily as might have been wished.

As long ago as about 1836 Messrs. Mather, Dickson & Co., of Liverpool, were amongst the first to adapt to fixed engines the locomotive boiler, pure and simple, but enlarged, and from the designs of Mr. John Grantham, C. E., the very large boilers, for that day, were constructed and fixed at Edgehill Station, for the supply of high-pressure steam to the fixed engines also constructed by them for working by rope traction the incline in the tunnel between there and Lime street. These boilers worked with economy and satisfaction for several years; we believe no objection was ever made to them but that of their considerable first cost. Many years ago, also, Messrs. Rennie employed for one or more engines in their works in London, a vertical boiler, consisting of a simple cylindric external shell, a drum fire-box inside, carrying above it a large number of vertical tubes, the gases from the whole of which were gathered into one central flue, which passed off directly from the top of the boiler. The water surface was necessarily below the top tube plate, and so a small length of the upper and cooler end of the tubes, and of the top tube plate, were exposed to contact with steam in place of water. This boiler, we were, ourselves assured by the late Mr. George Rennie while examining it, had then for some time continued to give them steam at high pressure, with a consumption of mixed coal and coke equivalent to not more than 2½ lbs. per hour per indicated horse-power.

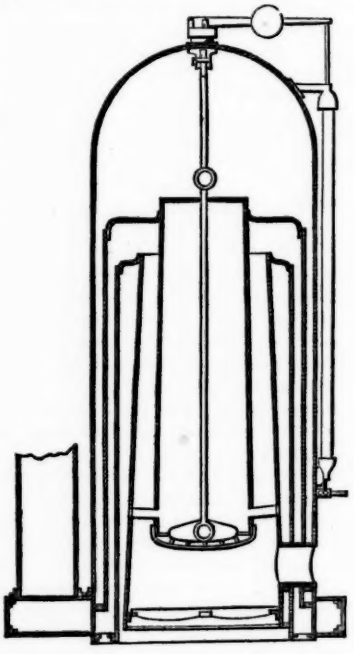
This form of fixed tube boiler, of great simplicity, and as great cheapness as any tube boiler perhaps is susceptible of, had even to a rather greater degree than the horizontal-tubed locomotive boiler the advantage of permitting easy repairs. The misfortune of all fixed tube boilers, which, for land work, are required as one of their primary conditions to be worked for long periods and perhaps without a moment's cessation, is, that the surfaces of the tubes, whether these are exposed exteriorly or interiorly to the water contact, coat and fur over with earthy matter, deposited or collected, and concreted from the water at a rate that is injurious to them, though less so with boilers exposing broad, flat, or curved surfaces to the water. The small tube is practically at all temperatures so nearly the same diameter that scale formed does not easily crack off spontaneously, while it has a much better chance of doing so from broad surfaces, which are continually changing their shape with variations of pressure, and their dimensions with difference of temperature. Mere length in tube does not seem capable of letting it clear itself thus of scale. Besides hard accretional scale, most natural water deposits more or less loose mud or sediment. Now, the horizontal locomotive tube form of boiler may be so made for fixed or land use, that most of this shall keep away and deposit clear of the tubes. This advantage, however, is not secured by the simple vertical form of tube boiler above described, as constructed by Messrs. Rennie; for the loose sediment, as well as any that may detach itself from the tubes, falls down and lies amongst the tubes, on the lower tube plate, and gradually passes thence by ebullition and currents in the boiling water, down to the bottom of the water wards of the fire-box; and it is at all times an unhappy arrangement when the sediment tends to deposit finally about some of the hottest parts of the boiler plates.

Another form of fixed tubular boiler, known as Inglis' in the north of England, and, we believe, the subject of a patent, was in use at the Elswick Works, near Newcastle, about 1863, and when we saw it, ap-

peared to have been working in a very satisfactory, and we learned, as we should have expected, in an economical manner. This boilers consists of two dome-topped cylindrical shells, of unequal diameter and height, connected together, above and below, by two cylindrical water flues, big enough for a middle-sized man to squeeze through. The larger cylinder contains the fire-box, and a smoke flue, rectangular in section, leading from the fire-box through the walls of both cylindrical shells, and into a cylindrical tube chamber in the center of the smaller cylinder, from whence a fasciculus of vertical tubes descends to the lower end or tube plate of the same cylinder. The whole boiler sits in brickwork, the ash-pit in front of the fire door being covered with a perforated cast-iron foot-plate.

Now most of the important conditions for tubular boilers are found here combined; every part, inside and outside, is as readily come-at-able as need be. There is ample circulation of the water, and a large surface both of fire-boxes and of tubes can be readily secured and well applied; moreover except as to the tubes themselves, scale has as a good chance of detaching itself here as in any other boiler of broad plates; there is ample room for the deposit of sediment, and by mud-hole doors can be made, so easily and so accessibly, that it can be periodically cleared out, if not removed even more frequently by mud cocks. It is also all pretty simple boiler-makers' work, both to make and to repair, and changes of dimension from hot to cold act systematically upon it, and tend little to rack its frame. It is, however, not a cheap boiler. When employed for uninterrupted service, the best mode of feeding it with water—and, indeed, this applies to every form of fixed tubular or lamellar boiler—would be to pass the feed water into a heating vessel of cylindrical form, placed in the horizontal flue, and so arranged that the sediment deposited in that could not enter the boiler, and should be easily removed from the vessel while the boiler continued at work.

A decided advance could be made thus upon the construction of multispaced fixed boilers, if we can abandon or reduce to the smallest extent tubes, and construct the boiler upon the lamellar principle instead; for then we shall substitute broad surfaces, which tend to keep clear from scale (under usual conditions), for small diametered tubes, which tend to clothe themselves with scale. This has been attempted in a multitude of forms—with flat water wards of one shape or another, as in Mr. Lamb's marine boilers; but such surfaces do not readily admit of the requisite strength for high-pressure steam, however admirably they may work under the conditions and moderate pressure of marine boilers.



The requisite conditions have been recently very well fulfilled, however, in the boiler patented by Messrs. Allibon & Manbre, the first named inventor, Mr. George Allibon, being of the Rosherville Ironworks, and anteriorly manager of the Millwall Ironworks, and since of the Worcester Engineworks. The engraving shows a vertical section of this boiler, the construction of which is so simple, that it will be understood almost without description by any one acquainted practically with boiler work. It consists of a vertical cylindrical shell (which may be of greater or less height to suit circumstances), containing four other shells nearly cylindrical, and so united that each alternate annular space is filled with water, while the other alternate ones afford, in a direction of movement up or down, passage for the gases of combustion of the fire, the

fire-box for which is in the bottom of the cylindrical and internal shell, on their way to the chimney.

The advantages secured by this boiler are pretty evident; it is very simple in workmanship, and admits of great strength. Two of the cylindrical internal shells are exposed to compression on their convex surfaces by the steam or water, but these can be easily and well stayed up to those against the interior or concave surfaces of which the pressure acts. The parts are easily pulled out one from the other for examination or repair, and with extremely little boiler work, or unmaking and remaking of joints. There will be but little fast scale, but the loose deposits will require to be passed off at intervals with regularity. In our own judgment the four short tubes of water communication between the central cylinder would be best put somewhat higher up, and a sediment box of parallel contour with the rounded bottom of this cylinder placed within it, and suspended from above. If judiciously placed, and the feed water (from an external heater always) properly introduced and led first into that suspended vessel, we think almost all sediment would take place therein, and all the rest of the boiler remain nearly free. Two conjugate boilers of this sort obviously might be made, and fired from one fire-box in one of them, something as in Inglis' boiler, and probably with advantage as to consumption of fuel. This form of boiler might be made very suitably applicable to the use of liquid fuel, assuming, what has not yet been properly done, that that fuel is burnt as vapor, mixed with its equivalent of atmospheric air previously heated to a sufficient temperature by the waste or other heat.

We entertain but little doubt that these boilers will prove safe, economical in work, and, at the very least, as much so in repair, as any known form of multispaced boiler. In respect to its central cylinder this boiler bears some little similitude to Mr. Thompson's "pot boiler," exhibited in 1867 at Paris; none whatever, in its general design, which is greatly superior to that of the pot boiler.

LARGE GAS HOLDER.—Mr. Thomas F. Rowland, of New York, has built, for the works in Twentieth street, New York, a gas holder 170 ft. diameter, by 70 ft. high, in two 35 ft. sections.

TECHNICAL EDUCATION IN FRANCE.

We quote from "The Engineer" a translation of the scientific syllabus of the Paris Conservatoire. Scientific lectures are read by eminent *savants*, not only at the Conservatoire, but at the Sorbonne, Collège de France, Jardin des Plantes, &c., and this practice constitutes a most important feature in the French educational system.* In France secular tuition is either very cheap or entirely gratuitous, without any restriction as to age, sex, nationality, or religious opinions of the students; in fact, no questions are asked as the student enters the lecture-room, provided he behave decently.

CONSERVATOIRE IMPERIAL DES ARTS ET METIERS — PUBLIC AND GRATUITOUS COURSES OF LECTURES ON SCIENCE APPLIED TO THE USEFUL ARTS, 1868–1869.

Geometry, Practical.—M. Baron Ch. Dupin, Professor; M. Lausedet, Assistant. Programme: Theory of the principal curves employed in the drawing and construction of machinery; diagrams of parts serving to transform motion; toothed wheels; cams; eccentrics; articulations; escapements; counters; registering instruments.

Geometry, Descriptive.—M. de la Gournerie, Professor. Programme: Rules of linear perspective, and geometric constructions referring to it; effects of perspective; instruments of perspective; curved pictures; perspective of bas-reliefs; stage scenery; rapid perspective.

Practical Mechanics.—M. Tresca, Professor.—Programme: General principles of mechanics; definitions; effect of forces; mechanical work; principle of the conservation of work; means of developing and employing mechanical work; passive resistances; uses of machinery; composition of engines; description and theory of machinery used in industry.

Civil Constructions.—M. E. Trélat, Professor.—Programme: Materials, classified according to their uses, and to the æsthetic expression that they afford; theory of the elements of construction; foundations; vertical and horizontal walls; roofs.

Practical Physics.—M. E. Becquerel, Professor. Programme: Fundamental laws of general physics; the applications of heat; formation of vapors; use of their elastic force; sources of heat; warming and ventilation; molecular action; general laws of acoustics; fundamental laws of light; sources of light; construction of optical instruments.

Practical Chemistry.—M. E. Peligot, Professor. Programme: First part of the course, general phenomena of combination and decomposition; equivalents, nomenclature and symbols; natural history of simple non-metallic bodies, and of their principal combinations; air; water; mineral acids; ammonia; useful metals.

Manufacturing Chemistry.—M. Payen, Professor. Programme: Composition of vegetable matter, cellulose, preservation of timber and grains; starch, dextrine, glucose, gluten, Italian pastes;

* See Van Nostrand's Magazine, No. 2, page 116.

food; hygiene; sugar manufactures; alcohol, wine, beer, cider; paper; soap, gelatine; hydro-carbons, petroleum, lighting and warming gas.

Agricultural Chemistry.—M. Boussingault, Professor. Programme: Experimental demonstration of the process of testing and analyzing substances produced or utilized by agriculture; means of detecting adulteration.

Agriculture.—M. Moll, Professor. Programme: Exposition of the special rules of agricultural zootechnia; breeding, rearing, and employing horned cattle, pigs, poultry, horses.

Rural Works.—M. Mangon, Professor. Programme: Agricultural hydrology; drainage; manufacture of drain pipes; cleaning drains; desiccation (drainage); polders; colmatage (manure irrigation); ponds; fish culture; irrigation with pure or muddy water; legislation on water; plantation of forests; grass; sand-hills; forest industry.

Spinning and Weaving.—M. Alcan, Professor. Programme: First process in hand and machine weaving; plain, curled, and figured webs; openwork and stocking web; cleaning and mechanical preparations; sewing, embroidery, and ornament machines.

Dyeing and Printing.—These lectures are not commenced yet.

Political Economy and Industrial (Factories) Legislation.—M. Wolowski, Professor. Programme: Division of labor and co-operation; barter; money; law of germinal an xi. (of the French republic); trust money (credit); exchange; contractors and workmen; strikes; trade unions; association.

Industrial Economy and Statistics.—M. J. Burat, Professor. Programme: On production; on the forces employed by production; natural forces, work, capital; on the principles and economic laws regulating the industry of agriculture, manufactures, and trades; on the institutions which facilitate production; weights and measures, bills of exchange, and means of credit; means of communication, roads, canals, railways.

PRESERVING TIMBER.

An abstract of a paper read at the meeting of the Chemical Section of the Philosophical Society of Glasgow, by Mr. P. M. Muir.

This paper was specially written to explain the methods that have been and are now in use for the preservation of timber from decay by disease and exposure to the atmosphere, or destruction by marine worms and insects.

Timber when exposed to the action of the atmosphere is soon acted on by damp. This is especially noticeable in all timber fixed in the ground. The action commences at the parts immediately above the surface of the ground, where the fibrous portions of the wood are softened by the moisture, mould and decay being produced. These are indicative of a sort of slow combustion which is set up by the alternations of wet and dry. This kind of wasting away is termed wet rot. Another and very destructive form of decay is that which is known as dry rot. This goes on most rapidly where there is no circulation of air. It is believed by some persons to be caused by parasites; but by others it is believed that the parasites only appear after the decomposition has set in, and that they appear and live to consume the materials which by their accumulation might render the earth and air unsuited to the essential conditions of life and health. There is some probability that dry rot is a result of the felling of timber while it is full of sap, that is, between the end of spring and the beginning of autumn. Another familiar form of disease is that which is caused by the Termite or white ant. This creature's operations prove very destructive in India, Ceylon, Brazil, and most tropical countries. Its attacks are most ravenous on all wood buildings, railway sleepers, and bridges, even though the constructive material be lignum-vitæ, one of the hardest and most durable of woods.

When timber is used in marine structures the destructive agents are greater enemies than decay by dry or wet rot. There are two of them which are the best known among salt water destructive agents, and are very ruinous to all wood erections which are unprotected from their ravages either chemically or mechanically. They are the *Teredo navalis*, or ship-worm, and the *Limnoria terebrans*. The teredo is a long worm-shaped creature which perforates timber generally in the direction of the grain, but sometimes across the grain with many windings. When a knot is met with, or the shell of another teredo, the creature accommodates itself to circumstances by bending from its original course. In a fir pile taken from the old pier of Southend a worm was found two feet long and three-quarters of an inch in diameter. Some have been seen three and even four feet long, and one inch in diameter. The teredo grows very rapidly, and its ravages are often very terrible on ships, piles, &c. The teredo is not nearly so prevalent on the Scottish coasts as in the South of England and on the coasts of France and Holland where unprotected timber is readily destroyed.

The *Limnoria terebrans* is very abundant around the British shores. Its ravages were first particularly observed in the year 1810, by the late Mr. Robert Stevenson, engineer of the Bell-Rock Lighthouse. The limnoria very much resembles a wood-louse, and is about 1-6 inch in length. It is gre-

garious, and in situations favorable for the exercise of its habits it soon produces great effects on the wood to which it attaches itself. By boing in all directions it so disintegrates the wood as to allow the sea to wash away its surface, and thus layer after layer of the wood is riddled by the borer, and then abraded by the sea until the whole piece of timber attached is completely destroyed.

Various opinions have been entertained regarding the mode in which the limnoria perforates and destroys timber, but the opinion expressed by Dr Coldstream after very careful observation seems to be the most worthy of credence. He states that the animal effects its work by the use of its mandibles, and it seems that it is necessary that the hole should be filled with salt water. The distance bored is from one to two inches long, and as the hole increases in size the animal leaves its old workings and begins new ones.

All kinds of timber in the unprepared state, except greenheart, are readily devoured by the limnoria, if used in harbor works not exposed to the influence of fresh or river water. Greenheart is not molested by the animal at all, but every other kind of wood is attacked immediately that it is put into the sea, whether afloat or fixed, but more readily if fixed. The boring is generally limited to that portion which is between two-thirds flood and the bed of the sea or estuary. The rate at which the limnoria bores into wood in pure salt water is said to be about one inch in a twelve-month; but instances have occurred in which the destruction has been much more rapid. At Greenock, for instance, a pile twelve inches square was eaten through in seven years. The limnoria cannot live in fresh water, hence it is not found doing any damage in the Clyde higher than Port-Glasgow.

Greenheart timber in its natural state is the only wood now in use for harbor works that is proof against the attacks of marine creatures, and those of the white ant in tropical countries. There are two reasons why it enjoys this immunity from attack: first, there is its great hardness; and, secondly, there is the presence of a large quantity of essential oil. It is a very hard and durable wood, weighing about 75 lbs. to the cubic foot, and having a specific gravity of 1.089, so that it is a little heavier than water. It is brought from Demerara. Great care is required in working it, as it is very liable to split. In sawing it is necessary to have all the logs bound tightly with chains, failing which precaution the log would break up into splinters, and be very apt to injure the men working it.

The author then proceeded to discuss the various mechanical and chemical methods that have been employed to preserve timber from natural decay or from the destruction effected by living creatures. The mechanical methods are wholly employed for marine purposes, and are the oldest in use. One of these consists in covering piles, between high and low-water mark, with flat-headed iron nails, the heads being about one inch in diameter, and the nails being driven in so close that the heads touch, but do not overlap each other. This method is expensive, both on account of the materials employed and the time required in the operation; and besides this it is very inefficient, as the nails readily corrode, and leave room for the attacks of the living enemies. Another plan is to cover the piles or other submerged timbers with sheets of zinc or copper. This also is an efficient means of protection.

For the preservation of wood by means of chemical preparations, although many patents have been taken out, not more than six have been worked commercially. In all cases these patents were obtained for the use of solutions of certain chemical compounds as preservative agents. The names of the patentees and the most valuable compounds employed are shown in the following table:

Kyan - - -	1832	Chloride of mercury.
Margary - -	1837	Sulphate of copper.
Bethell - -	1838	Creosote or pitch oil.
Bethell - -	1848	
Burnett - -	1838	Chloride of zinc.
Burnett - -	1840	
Boucherie - -	1839	Pyrolignite of iron.
Boucherie - -	1846	Sulphate of copper.
Payne - - -	1841	Sulphate of iron.
Payne - - -	1846	Carbonate of soda.

The methods employed practically in working these patents were three in number, namely, steeping, vital suction, and pressing in close vessels. Kyan and Margary employed the first-mentioned method; Boucherie employed the second; and Payne, Burnett and Bethell employed the third, which was also latterly adopted by Boucherie. The first and third methods required that the timber should be seasoned and free from sap.

The author described each patented process at some length, mentioning how it is

carried out, the advantages and disadvantages in each case, and the conditions under which it has any practical benefit. In no case did the evidence regarding the value of the process seem to equal that in favor of the creosoting process patented by Bethell, at all events if the timber is to be exposed to the weather or to be used in structural works which are subjected to the action of either fresh water or salt water.

Kyanising, or injecting corrosive sublimate (chloride of mercury) into timber, is very expensive if properly done; and besides this there is the fact that it is practically useless, inasmuch as it has been found that kyanised piles, after three years' immersion in the sea, did not contain a trace of the preservative compound.

Sulphate of copper, first suggested as a preservative agent by Margary, and afterwards employed largely by Boucherie, may be used to prevent dry rot in timber; but for piers, bridges, railway sleepers, and other structures which are exposed to the action of water, it has no practical value, as the water dissolves out the salt with great rapidity. Timber prepared with this salt, and used for marine purposes, is as readily destroyed by the teredo and the limnoria as unprepared timber.

In Payne's process solution of sulphate of iron is first absorbed into the wood, and afterwards carbonate of soda. Double decomposition ensues, and the practical result is the formation of oxide of iron, the deposition of which renders wood brittle, and does not prevent the attacks of either of the animals just named.

Of Sir William Burnett's chloride of zinc process the author could say nothing from personal experience. The essential part of the chemical action of the compound is the formation of an insoluble coagulum with the albumen of the wood. It is claimed for the Burnett process that it renders wood proof against the attacks of the white ants in India; and wood for in-door purposes is permanently improved by it.

Bethell's patent process for preserving timber by the use of creosote pitch oil is the only one which really accomplishes the object aimed at, although many patents for the use of oleaginous substances had been secured prior to the year 1838, with the same object in view. Creosote acts very powerfully in coagulating the albumen contained in the cells of the wood, and besides this it effectually preserves the fiber of the timber, and hence its value over all other so-called preservative agents.

The apparatus required in the creosoting process consists of an injecting cylinder, generally about six feet in diameter, and varying from 30 feet to 70 feet long, together with exhaust and pressure pumps, an oil tank, and the requisite piping connexions. It is not unusul to have both ends of the cylinders open, so that the timber may be entered at one end and removed at the other with the greatest facility, and to have them fitted with air-tight iron doors, which are removable at pleasure. When the cylinder is charged with timber, and the door or doors properly secured, the air is extracted by the air pump, both from the interior of the cylinder and from the pores of the wood. A vacuum being produced in the cylinder, the oil, which has been heated in the tank by steam pipes to a temperature of about 120° fahr., is allowed to rush in, and when the cylinder is full, the inlet pipe is shut and the pressure pumps are started to force the oil into the wood, the pressure being maintained at from 150 lbs. to 200 lbs. on the square inch until the wood has absorbed the required quantity of oil, which is learned by reference to an index gauge. For land purposes the amount of oil recommended is eight lbs. to the cubic foot of wood, and for marine purposes from 10 to 12 lbs. per cubic foot. In France, Belgium and Holland, the quantity used varies from 16 lbs. to 26 lbs. per cubic foot when the timber is intended for marine works. Beech wood has absorbed as much as 31 lbs. of oil per cubic foot, and when used for railway platforms or harbor works, it is doubtless the cheapest and most durable material that can be used.

Creosote (or pitch oil, as it is more commonly called in Scotland) is obtained in the distillation of coal tar, the other ingredients being ammoniacal liquor, crude naphtha, and the residual pitch. The coal tar of Scotch gas works generally yields about 25 per cent of oil which distils over at temperatures ranging from 400° to 700° fahr.; in England, however, the amount is only about 20 per cent. The author estimates the annual yield of pitch oil in Scotland at one million gallons, almost the whole of which is used for creosoting purposes. It is probable that creosote owes its valuable antiseptic property to the presence in it of from five to fourteen per cent of crude carbolic acid, but which could not be used by itself for outdoor purposes, as it is slightly soluble in water.

According to Dr. Letheby, creosote acts as a preservative agent in the following ways:

1st. It coagulates albuminous substances and gives stability to the constituents of the cambium and cellulose of the young wood.

2d. It absorbs and appropriates the oxygen which is within the pores of the wood, and so checks, or rather prevents the eremacausis of the ligneous tissue.

3d. It resinifies within the pores of the wood, and in this way shuts out both air and moisture.

4th. It acts as a positive poison to the lower forms of animal and vegetable life, and so protects the wood from the attacks of fungi, acari, and other parasites.

Since the creosoting process was first introduced in the year 1838 it has been extensively employed in Great Britain and Ireland; in all countries on the continent where creosote oil can be obtained—France, Holland, Belgium, Germany, Spain, Portugal, and Italy; and in India, Cape Colony, Brazil, and other tropical countries, to preserve timber from the attacks of the white ant. Wherever it has been properly carried out it has been completely successful.

Of late, many railway companies have discontinued the use of creosoted sleepers, not from any failure of the process, but from the wear and tear of the sleepers caused by the chairs cutting down into them and gradually rendering them useless. This mechanical injury to the sleepers would be greatly lessened were the base of the chair made broader. According to Mr. Deas, late engineer on the western section of the North British Railway, it will doubtless be less and less the practice of railway companies in this country, under the present financial depression, to creosote or otherwise preserve their sleepers, as the cost of the operation—6d. to 8d. per sleeper—is such a high proportion to the original cost of the sleeper, which is generally from 2s. 2d. to 2s. 6d. for each, while, owing to the cutting-down action of the chairs, the prepared sleeper becomes useless for permanent wear almost as soon as one unprepared.

For harbor works in Scotland the creosoting process has been largely used. At Leith, the west pier, consisting of 1,013 main piles, is entirely constructed of creosoted timber, and the extension of the east pier contains 312 main piles, also creosoted.—These erections were commenced in 1848, and finished in 1853, and at the present time they are as perfectly sound as the first day they were put down. The gates of the new dock now being constructed at that port are made of creosoted pine bound with greenheart timber, the quantity of oil used being ten lbs. per cubic foot. At Glasgow all the wooden wharves, with the exception of the steamboat quay, are constructed of creosoted pine, eight lbs. of oil to the cubic foot. The whole of the wharves at the Kingston Dock are built of creosoted wood, the same quantity of oil being used. At Port-Glasgow and Greenock timber prepared by the Bethell process is largely used, and the same is true of nearly every port in England. Much attention has been given to the creosoting process by the Belgian Government, and so satisfactory have the experiments been that no other process is used by that government. Very full and interesting accounts of the Belgian experiments upon the creosoting process have been prepared by M. L. Crepin, ingénieur des Ponts et Chaussées, especially in "Annales des Travaux Publics de Belgique," vol. xxi., 1864. M. Crepin affirms that wood retains all its former elasticity in the creosoted state, and acquires a density which it did not possess in the unprepared condition. M. A. Forestier, engineer-in-chief for the department of La Vendee, made a very minute and elaborate report for the Paris Exhibition of 1867 on the creosoting process and experiments made with it on timber used in both land and marine works in France; and in that country the process is also largely employed.

HOW STEREOTYPE-PLATES ARE MADE.

From the "American Artisan."

The surface of the types, set up as for printing, is first treated in the same manner as for electrotyping, except that it is oiled instead of being coated with black-lead. This being done, what is technically called a flask, simply a kind of rectangular frame is placed upon the chase. Plaster-of-Paris brought to the suitable consistency with water is then poured into the flask and upon the surface of the type locked up in the chase, and suffered to harden. This being done, the plaster mold thus formed is brought away from the chase, and consequently from the face of the type, by means of screws arranged at the corners of the flask. By this means the surface of the mold is kept intact from injury, which would occur if the move-

ment of the flask in removing the plaster from the projecting faces of the type were irregular, or even very slightly in a lateral direction. When the mold has been completely detached from the face of the type it is fitted into a cast-iron pan, and both pan and mold are sunk to the bottom of a caldron of melted stereotype metal, which is somewhat different from, although closely resembling, ordinary type metal. This caldron is, of course, arranged over a suitable surface. The mold is suffered thus to remain in the molten metal until the heat of the latter has completely dissipated all the moisture of the mold, so that the metal penetrates without blowing into all the interstices of the mold. The mold being lifted from the caldron is filled with the molten metal, which on cooling constitutes the stereotype, requiring only the finishing operations of planing to thickness and the like to fit it for use in printing. These, being substantially the same as in the case of electrotypes, require no further description here. It should be mentioned, however, that previous to being thus finished, the plaster or material that may adhere to the plate must be removed therefrom by thorough washing, facilitated by the active application of a brush.

It is sometimes preferred that the plates should be cast in clay molds, instead of in those formed of plaster, the clay taking a better impression of low space work than the plaster, and having the additional advantage that it does not fill up the faces of the type like the plaster; this advantage obviating all necessity for cleaning the type after forming the mold, as is essential in the other case.

The material of which the clay molds are formed is common kaolin or potter's clay, mingled with powdered soapstone and properly tempered. Previous to use it is wrought and worked up with a solution of gum-arabic, and a little plaster is added.—Being brought to the requisite condition and consistency, it is spread upon the platen of a press, and the impression of the type or other surface is taken in the same way that the impression upon wax is taken in the preliminary part of the process of electrotyping. The clay thus impressed forms the mold that is to be, and is dried either in an oven contrived for the purpose, or by simply placing it upon the top of an ordinary furnace.—When the clay molds have become thoroughly dried, they are placed one over another and surrounded by metallic frames, which not only serve to close their sides, but also to keep them the requisite distance apart. When thus arranged the molten metal is poured into the spaces between and on cooling forms the stereotype-plates in the same manner as if cast in the separate plaster molds. Plates may be cast more cheaply by the use of the clay-molds than by the others, and for all ordinary purposes the work is just as good. Where fine and sharp impressions are required, however, there is no mode of stereotyping that gives as good results as the plaster method.

As an addenda to the above description of the manner of making stereotypes practiced by Messrs. Lovejoy, Son & Co., we give a brief sketch of another process—the *papier-maché* process—employed in making the plates used in printing the large editions of some of the morning papers of this city, for which the simple forms of type alone would be wholly inadequate.

In carrying out this process a sheet of blotting paper of suitable size is covered on one side with a coating of paste prepared especially for the purpose, and upon this, and carefully smoothed with the hand, is placed a sheet of tissue-paper. This sheet it cut into pieces corresponding in size to the pages to be stereotyped, and each piece is coated on its face or tissue side with finely-powdered French chalk, applied with a soft brush. The surface of the page of type is sparingly coated with salad-oil, and the paper, face downward, is laid upon the surface of the type. This being done, a piece of damp linen is laid upon the back of the paper, and the paper is then beaten down upon the surface and into the type by means of what is known in the trade as a beating-brush, care being taken to bring the brush flatly down upon the paper at each stroke. When the paper has been well beaten into the type in this manner the cloth is removed, a piece of cartridge-paper is pasted upon the back of the paper matrix just formed, and the beating operation is repeated. This being done, the matrix, still upon the type, is subjected to the action of a press, and afterwards suffered to dry somewhat, which ordinarily requires but a few minutes, after which the matrix is gently lifted and separated from the type.

In casting the plate the matrix is fitted in what is termed a mold, and the metal is poured in, and, filling the mold, on cooling forms the plate, which, if all the various operations of the process have been properly

carried on, easily separates from the matrix, and by a few finishing touches is rendered fit for use.

This *papier-maché* process has the advantages of cheapness and quickness in making the plates, and the latter are about equal in quality to those made in the clay molds above described. It is found, however, that the beating of the paper upon the type destroys, in time, the hair lines upon the latter, and thus impairs their value. Another objection to this plan lies in the deterioration of the type-metal, which is found to occur, for some unexplained reason, when the metal is cast upon the paper material of the matrix.

COMMUNICATION BETWEEN ENGLAND AND FRANCE.

From "Engineering."

The prospects, engineering and commercial, of a tunnel beneath the Dover straits, the possibility of constructing such a work, and the chances of a profitable issue if it were ever completed, are at last in a fair way of being thoroughly investigated and decided, so far as it is possible for able engineering foresight to decide them. It is at least a satisfaction to know that the idlers who, with scarcely capacity to lay a water main, treat the construction of twenty-five miles of submarine tunnel as a mere trifle, will perforce cease from troubling with their visionary executive and revenue estimates when a sound opinion has been given on the matter. It is but just, however, to all these schemers to admit, that their perseverance has done something to impress the fact that the present means of communication with the Continent are eminently inefficient and unsatisfactory.

It *may* be, for the limits of possibility cannot be set, that the next generation will see the completion of a railway ligature joining France and England, and that the traffic will have increased so enormously as to pay the high dividends which alone could remunerate the venturous capitalists for their precarious investment. But this, as yet, is beyond the province of sober belief; and there is no reason to imagine, as the advocates of the Channel Tunnel would have us imagine, that passengers would travel in millions beneath the bed of the sea, instead of in thousands on its surface, or that, to the popular mind, an hour of mental agony in a tunnel would be welcomed in exchange for sixty minutes' physical discomfort on the surface. Assuming, however, for a moment that such a scheme has been pronounced feasible, and that the twelve millions or so have been raised for the work, England and the Continent would have to wait patiently for, perhaps, a quarter of a century till the tunnel was completed; so that, at least pending the construction of this great undertaking, we must look for some efficient, if only temporary, means for superseding the present miserable accommodation.

Such a plan is offered by Mr. John Fowler, and the other engineers associated with him, in his English and Continental Intercommunication scheme, deposited last Session, and postponed till next year, for the adjustment of preliminary arrangements, and for the further consideration of the project. It is, indeed, no matter for regret that, publicly, the bill will lie dormant till next Session, for the interval will give time for present opposition to be converted in future co-operation, while the agitation of the permanent communication advocates will urge forward the undertaking.

The route chosen for the crossing is from Dover to Audrecelles, which latter port offers far greater advantages than does the coast at Calais. A shorter course—only 23 miles from dock to dock—deeper water, an absence of shifting sand-banks, and a complete protection from the easterly and north-easterly winds under the lee of Cape Grisnez, whose lighthouse would direct the course, are among the obvious advantages of the new proposed route. The construction of a few miles of railway from Audrecelles to Wimereux, will save the journey from Calais to the latter station, and shorten the distance to Paris by fourteen miles, although of course travelers to Brussels and towards the north would suffer this disadvantage now incurred by those who have Paris for their destination. As the former class of travelers are, if anything, a little more numerous than the latter, it follows that the traffic of the railway would be increased by the change of landing places, even if the increased facilities of crossing did not stimulate travel. But of this there can be no doubt, although not in the extravagant degree claimed by the tunnel advocates, who must look forward to an unceasing stream of about 250 passengers per hour throughout the year, and an increase of goods' traffic in like degree, to earn a revenue sufficient to

pay their dividends and maintenance expenses. This *may* come in the future, created by the submarine link, but so far as we can see there is not a single advantage, claimed for the permanent communication, which is not possessed by the ferry, whilst the latter scheme is, on the other hand, free from the objections fatal to the tunnel.

A moderate capital, easily obtained, would suffice in a short time to establish a perfectly efficient and satisfactory service, that would so far encourage and increase traffic as to produce a revenue representing a large return upon the outlay. The railway companies, both English and Continental, would obtain corresponding advantages with the increasing traffic promoted by the new service, and above all, of far more importance than the new comfort derived by passengers, a satisfactory means of transporting merchandize would be gained, and the delays and injuries to which goods are now constantly exposed would be avoided. Concentrating at Audrecelles from all parts of Europe, the goods' wagons would be transported to the opposite dock to the benefit of the Chatham and Dover and of the South-Eastern Railways, which would necessarily secure through the ferry the bulk of the merchandize that is now exported for the various shipping places of the Continent to the English ports.

Offering all these advantages, we cannot doubt that the English and Continental Intercommunication bill will be freely passed next Session, and that the works will be commenced without delay. The public and the railway companies are alike interested in its completion, and though it *may* have in its turn to give place to a permanent communication, it will have probably a half century of good service without competition, and it would afterwards doubtless be leased, and kept in working order by the tunnel company, in the event of any contingency, to which that great work, after its completion, might in the course of nature be liable.

THE PENNSYLVANIA IRONWORKS, Chester, Pa., have closed a contract with parties in New York for the building of a number of iron steam-colliers for the coasting trade, having a carrying capacity of about 600 tons. They are only the pioneer vessels of a projected large fleet for cheaply transporting coal from the most convenient points of shipment to consumers. Some railway companies are interested inthe enterprise.

THE INDICATOR.

PRACTICAL DIRECTIONS FOR APPLYING AND TAKING CARE OF THE INSTRUMENT.

From Porter's "Richard's Steam Indicator."

I.

OF ATTACHING THE INDICATOR.—When it is practicable, diagrams should be taken from each end of the cylinder. The assumption commonly made, that if the valves are set equal, the diagram from one end will be like that from the other, will be shown by this instrument to be erroneous. This is owing to the difference in the speed of the piston at the opposite ends of the cylinder, which is, at the outer end of a direct-acting engine, from 35 per cent to 66 per cent greater than at the crank-end, the difference varying according to the degree of angular vibration of the connecting-rod. In side-lever or beam-engines, these proportions are reversed, and the speed of the piston is greater at the upper end of the cylinder. Often, also, there is a difference in the lengths of the thoroughfares, and in the lead, or amount of opening, or the point closing; and many times the valves are supposed to be correctly set, when this Indicator will show that they are not. These and many other causes, will make a difference in the diagrams obtained from the opposite sides of the piston.

One use of the Indicator is in fact to show whether or not the diagrams from opposite ends of the cylinder *are* alike.

PIPES TO BE AVOIDED.—The Indicator should be fixed close to the cylinder, especially on engines working at high speeds. If pipes must be used, they should not be smaller than half an inch in diameter, and five-eighths in the bends, and as short and direct as possible. Any engineer can satisfy himself with this instrument, that each inch of pipe occasions a perceptible fall of pressure between the engine and the Indicator, varying according to its size and number of bends and the speed of the piston. Diagrams have been known to show, from this cause alone, 40 per cent less pressure than was actually in the cylinder. Probably the diagrams taken from engines, generally show in nine cases out of ten, the lead or the pressure or both, untruly, from the incorrect manner in which the instrument is attached.

WHERE TO CONNECT THE INDICATOR.—On vertical cylinders, for the upper end, the

Indicator cock is usually screwed into the cover. Sometimes it is attached where the oil-cup is set, this being removed for the purpose. For the lower end, it is necessary to drill into the side of the cylinder, at a convenient point in the space between the cylinder bottom and the piston, when on the center, and screw in a short bent pipe, with a socket on the end to receive the Indicator cock. This Indicator can be used in a horizontal position, but it will be found much more convenient to put in a bent pipe, and set it vertical. Sometimes it will be necessary to drill in the side of the cylinder at the upper end also, especially in double cylinder engines having parallel motions, when the Indicator cannot generally be set on the covers. Care must be taken that the piston does not cover the hole when on the center. No putty is necessary to make these small joints, and it should never be used, as it is liable to clog the instrument. If the screw fits loosely, a few threads of cotton wound round the stem will prevent the escape of steam.

On horizontal engines, the best place for the Indicator is on the top or upper side, at each end; if it cannot be placed there, bent pipes may be screwed into the covers or into the side of the cylinder. In other respects follow the directions given for vertical engines. The Indicator should never be set to communicate with the thoroughfares. The current of steam past the end of the pipe or the hole reduces the pressure in the instrument, and the diagram given is utterly worthless, as any engineer can readily ascertain by making the experiment.

The stop-cock being screwed firmly in its place, screw the Indicator down to its seat, turning it to the most convenient position, and make it fast by turning the coupling; then move the guiding-pulleys to their proper position to receive the cord, and the instrument is in readiness for use.

II.

Of Giving Motion to the Paper.—*The Drum the best Means.*—The revolution of a drum is probably the most correct as well as convenient method of giving motion to the paper. It may be supposed that a flat slide, worked by positive means, would have a perfectly accurate motion; but, in fact, at high velocities, where alone any trouble is met with, the difficulties involved in its use are more troublesome than those presented by the cylinder. In most cases the connecting-rod must necessarily be somewhat long; it must not tremble, or the line on the paper will be tremulous, and the weight required for stiffness, joined to the weight of the slide, causes a momentum, which, if the rod is worked by a vibrating arm, will give to the paper, on each center, a motion opposite to that of the piston of the engine; and precisely at these points it is of the greatest consequence that the two motions shall coincide.

In the use of the cylinder at any speed, the question of obtaining a positive motion, if there is no elasticity in the cord or the parts to which it is connected, is simply one of proportion between the momentum of the revolving parts and the strength of the spring by which this is resisted. In this Indicator these parts are made as light as possible, consistently with other requirements, and the spring is of such strength that they may be reciprocated from 250 to 300 times per minute, without any increase in the length of the diagram, and of course, therefore, without any error in the motion. There is no difference in the construction of these Indicators in this respect, it being intended that every instrument shall be applicable to any engine.

From what Points to derive the Motion.—This may be taken from any part of the engine which has a motion coincident with that of the piston. For a beam-engine a point on the beam, or beam-center, or on the parallel-motion rods where these are employed, will give the proper motion; but care must be taken that the cord be led off in the right direction—a requirement which is sometimes overlooked; afterwards its direction of motion may be changed as required.

In some cases it is most convenient to take the motion from a point on the end of the revolving shaft; this is frequetly the case on horizontal engines, working at high speeds, because then the motion does not need to be reduced. Exact accuracy cannot be got in this way, however, without employing a moving slide and connecting it with the pin in the end of the shaft by a rod or cord of such length that its angular vibration shall be the same as that of the connecting-rod. This will be found generally a troublesome matter, and the engineer will probably prefer, in most cases, to disregard the error resulting from its omission—which is, that the motion of the paper will be more nearly equal at the two ends of the

stroke, being slower than that of the piston at the one end, and faster at the other. The crank or pin from which the cord receives its motion must be on its center, relatively to the direction of the cord, whatever that direction may be, precisely when the crank of the engine is on *its* center. If this requirement is not carefully attended to, the diagram will be worthless. Generally, on horizontal engines, the motion of the paper is taken from the cross-head. In an engine-room, a strip of deal board may be suspended from the ceiling in such a manner as to permit it to swing backward and forward, edgeways, by the side of the guides, and motion may be given to it by a pin secured firmly to the cross-head, and projecting through a slot in the board, in which it should fit nicely to prevent lost time on the centers. The board must hang plumb when the piston is in the middle of its stroke. The cord may be connected to this strip of board at a point sufficiently near to its point of suspension to give the required reduction of motion for the paper, and must be led off in a horizontal direction, and then over one or more pulleys in any required direction to the Indicator. At high speeds, however, pulleys should be avoided. On portable engines, the motion may be obtained in the manner just described, the lever swinging from a pin supported in a standard about two feet in height, set on one of the guide-bars.

On locomotives having outside connexions, the motion must be taken from the cross-head. It is indisputably necessary to use only a short direct cord, free from elasticity, and connected to a point, the motion of which is reduced from that of the cross-head by positive means. Care must be taken also to so proportion the parts employed for this purpose, that the point at which the cord is connected shall have a positive motion without any fling, a matter not by any means free from difficulty at 250 revolutions per minute. A rock-shaft, turning in bushings, supported by two angle iron standards precisely over the mid-position of that point of the cross-head from which the motion is derived, affords perhaps the best means of reducing the motion. A long-arm is worked by the cross-head, and a short-arm gives motion to the cord. The short-arm must be keyed in such a position that when the piston is in the middle of its stroke it will stand at right angles with the direction of the cord, whatever that may be.—The direction of the cord may form any necessary angle with the horizontal line, but must be at right angles with the rock-shaft. On locomotives having inside connexions, and a single pair of driving-wheels, where it is practicable, it will be found the better way to take the motion from a pin set in the end of the shaft, and to communicate it by a connecting-rod to a point convenient for attaching the cord. The parts should be all substantially made; the momentum of the connecting-rod will be perfectly resisted by the pin. On oscillating engines, the motion may be taken from the brasses at the end of the piston-rod. If the stroke is long, it is sometimes difficult to reduce this motion to that required for the paper, and in such cases it is necessary to take the motion from an eccentric on the main shaft, to a point as near as possible to the trunnion, and thence to communicate it to the Indicator. In all these connexions, it is of the first consequence that there be *no* lost time which will require to be made up on every center, and will thus cause the paper to stand still while the piston is moving.

Pulleys of different diameters on the same spindle have been often used as a means of reducing the motion from that of the cross-head, but we do not recommend them; at high speeds it is very difficult to make them answer. The experience of the careful operator will teach him to guard against the various causes of error here mentioned, and others which will arise in the great diversity of situations in which the Indicator is used, and the effects of which are the more mischievous, because often the diagram itself furnishes no means of detecting them. The mathematician will perceive that *perfect* accuracy of motion is attained by only a very few of the methods here suggested. Most of them are only approximately accurate, but they are the best which can be readily employed, and the errors which they involve are too slight to be of practical moment. For the professional engineer, of course, directions are unnecessary.

III.

How to take a Diagram.—*To fix the Paper.*—Take the outer cylinder off from the instrument, secure the lower edge of the paper, near the corner, by one spring, then bend the paper round the cylinder, and insert the other corner between the springs. The paper should be long enough to let each end project at least half an inch between

the springs. Take the two projecting ends with the thumb and finger, and draw the paper down, taking care that it lies quite smooth and tight, and that the corners come fairly together, and replace the cylinder. The spring used on this Indicator for holding the paper will be found preferable to the hinged clamp. A little practice, with attention to the above directions, will enable any one to fix the paper readily.

The marking-point should be fine and smooth, so as to draw a fine line, but not cut the paper. It may be made of a brass wire; the best material is gun-metal, which keeps sharp for a long time, and the line made by it is very durable. Lines drawn by German silver points are liable to fade. A large-sized common pin, a little blunted, answers for a marking-point very well indeed; a small file and bit of emery cloth used occasionally will keep the point in order.

To Connect the Cord.—The Indicator having been attached, and the correct motion obtained for the drum, and the paper fixed, the next thing is to see that the cord is of the proper length to bring the diagram in its right place on the paper—that is, midway, between the springs which hold the paper on the drum. In order to connect and disconnect readily, the short cord on the Indicator is furnished with a hook, and at the end of the cord coming from the engine, a running loop may be rove in a thin strip of metal, in the manner shown in the following cut,

so that it can be readily adjusted to the proper length, and taken up from time to time, as it may become stretched by use. On high-speed engines, it is as well, instead of using this, to adjust the cord and take up the stretching, as it takes place, by tying knots in the cord. If the cord becomes wet and shrinks, the knots may need to be untied, but this rarely happens. The length of the diagram drawn at high-speeds should not exceed four and a half inches, to allow changes in the length of the cord to take place to some extent, without causing the drum to revolve to the limit of its motion in either direction. On the other hand, the diagram should never be drawn shorter than is necessary for this purpose.

To take the Diagram.—Everything being in readiness, turn the handle of the stop-cock to a vertical position, and let the piston of the Indicator play for a few moments, while the instrument become warmed. Then turn the handle horizontally to the piston in which the communication is opened between the under side of the piston and the atmosphere, hook on the cord and draw the atmospheric line. Then turn the handle back to its vertical position and take the diagram. When the handle stands vertical, the communication with the cylinder is wide open, and care should be observed that it does stand in that position whenever a diagram is taken, so that this communication shall not be in the least obstructed. The instrument is provided with a stop, to prevent the marking point from tearing the paper. The arm is to be pressed firmly up to this stop. If the line drawn is faint, the point must be screwed up and back if the line is too heavy. The elasticity of the parallel arms gives the light pressure required on the paper. As the hand of the operator cannot follow the motions of an oscillating cylinder, it is necessary that the point be held in contact with the paper by a light spring, and instruments to be used on engines of this class are furnished with an attachment for this purpose. Diagrams should not be taken from an engine until some time after starting, so that the water condensed in warming the cylinder, &c., shall have passed away. Water in the cylinder in excess always distorts the diagram, and sometimes into very singular forms. The drip-cocks should be shut when diagrams are being taken. As soon as the diagram is taken, unhook the cord; the paper cylinder should not be kept in motion unnecessarily, it only wears out the spring, especially at high velocities. Then remove the paper, and minute on the back of it at once as many of the following particulars as you have the means of ascertaining, viz:

The date of taking the diagram and scale of the Indicator.

The engine from which the diagram is taken, which end, and which engine, if one of a pair.

The length of the stroke, the diameter of the cylinder, and the number of double strokes per minute.

The size of the ports, the kind of valve employed, the lap and lead of the valve, and the exhaust lead.

The amount which the waste-room, in clearance and thoroughfares, adds to the length of the cylinder.

The pressure of steam in the boiler, the diameter and length of the pipe, the size and position of the throttle (if any), and the point of cut-off.

On a locomotive, the diameter of the driving wheels, and the size of the blast orifice, the weight of the train, and the gradient, or curve.

On a condensing-engine, the vacuum by the guage, the kind of condenser employed, the quantity of water used for one stroke of the engine, its temperature, and that of the discharge, the size of the air-pump and length of its stroke, whether single or double-acting, and, if driven independently of the engine, the number of its strokes per minute, and the height of the barometer.

The description of boiler used, the temperature of feed-water, the consumption of fuel and of water per hour, and whether the boilers, pipes and engine are protected from loss of heat by radiation, and if so to what extent.

In addition to these, there are often special circumstances which should be noted.

IV.

How to Keep the Indicator in Order.—The Indicator will not continue to work well, unless it is kept in good order. When used, it generally becomes full of water, which will rust and thus weaken the spring, and the steam often contains impurities and grit, a portion of which is lodged in it. After the Indicator has been used, and before putting it up, unscrew the cover of the cylinder case, and draw off the upper ferule, with the pencil movement and the piston and spring attached, empty the water from the cylinder case, carefully clean and dry all the parts, and replace them, lubricating the cylinder with a few drops of oil which is entirely free from gum. The cylinder is not to be removed from the case under any circumstances; the operation above directed gives complete access to it.

Sometimes the surfaces of the piston and cylinder become scratched or roughened by impurities in the steam, a fact which will be detected at once in the diagram by the unsteadiness of the line. If this shows the existence of any obstruction to the perfectly free action of the Indicator, take the instrument apart, as for cleaning, and remove the spring, then replace the piston in the cylinder after cleaning and lubricating them; screw on the cover to guide the stem, and rub the piston up and down in the cylinder, at the same time revolving the stem between the thumb and finger. The surfaces will quickly wear each other smooth; no grinding or polishing material should be used, but the piston should be taken out once or twice during the operation, and the surfaces cleaned. The piston, if dry, ought to drop perfectly free from every position. Before replacing, lift the levers and let them fall, to see if their action also is entirely free.—Then replace everything, taking care to screw the heads of the spring firmly up to the piston and cover. The paper cylinder requires to be lubricated occasionally with a drop or two of pure oil applied at the end of the arbor, also the leading pulleys and the joints of the pencil movement.

V.

How to Change the Springs.—Unscrew the coupling from the end of the piston-stem, the cover from the cylinder-case, and the spring from the piston and cover; introduce the new spring, and screw all up firmly again.

The length of the springs for the different scales are so proportioned to each other, that the pencil will always come to the proper position for drawing the atmospheric line. In putting in the spring No. 1, the head from which the barrel projects to stop the compression of the spring should be screwed to the cover and not to the piston. Be careful that the heads are screwed up firmly to the piston and cover.

The spring which gives reaction to the paper cylinder is liable to break after considerable use, especially on engines running at high-speeds, for which reason this cylinder should never be left to run unnecessarily. When breakage occurs a new spring can be readily substituted, as follows: set the Indicator on the engine, if there is no other convenient means for holding it firmly, and remove the cover of the spring case and the broken spring. Then hook the new spring on to the hook projecting from the ferule on the arbor, coil it into the case, and hook the end on the rim; see that it is coiled in the same direction with the cord. If the string has not sufficient strength to keep the cord quite tight, another coil must be given to it, but it should not be coiled any tighter than is necessary for this purpose.

Prices of Springs and Metallic Paper.—The springs and metallic paper may be procured from any parties who sell these Indicators. The springs will be sent

free by post to any address, on receipt of the price in stamps.

	Prices. £	s.	d.
Piston springs, with boxwood scales, each.	0	10	0
Paper cylinder springs	0	1	6
Quire of metallic paper, cut into 360 diagram sheets	0	4	0

Indicators for special purposes, or containing special modifications, will be made on application.

THE CENTRIFUGAL FORCE OF BELTS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

From "The Engineer."

Object of this Communication.—It is well known, through practical experience, that a belt for communicating motion between two pulleys requires a greater tension to prevent it from slipping when it runs at a high than at a low speed. Various suppositions have been made to account for this—such as that of the adhesion to the belt of a layer of air, which at a very high speed has not time to escape from between the belt and the pulley. But the real cause is simply the centrifugal force of the belt, which acts against its tension, and therefore slackens its grip of the pulleys. I have not hitherto seen or heard of any investigation of the laws of the action of centrifugal force on belts and other flexible connecting bands in machinery; and therefore, although it is unlikely that the subject has up to this time wholly escaped the notice of mathematicians, it appears to me that it may be useful to publish an account of the general nature of such an investigation and a statement of the practical rules to which it leads.*

For brevity's sake, the word "band" will be used throughout this paper to denote any flexible connecting piece by means of which motion is communicated between pulleys, whether a belt, a cord or a chain.

Centrifugal Tension of an Endless Band.—The general principle of the tension produced in an endless band by centrifugal force is closely analagous to that which forms the foundation of the "hypothesis of molecular vortices," a hypothesis proposed in 1849† as a means of deducing the dynamical theory of heat from the general laws of dynamics, viz.: that a vortex or endless circulating stream produces an outward pressure against the inside of any vessel within which it may be contained, of an amount proportional to the weight of matter contained in an unit of length of that stream, and to the square of its velocity, and independent of the figure of the stream; for it can be proved, from the elementary laws of dynamics, that if an endless band of any figure whatsoever runs at a given speed, the centrifugal force produces an uniform tension at each cross-section of the band equal to the weight of a piece of the band, whose length is twice the height from which a heavy body must fall in order to acquire the velocity of the band.

In symbols, let w be the weight of an unit of length of the band; v the speed at which it runs, and g the velocity produced by gravity in a second (=32·2 ft. or 9·81 meters); then the *centrifugal tension* (as it may be called) has the following value:

$$\frac{w\,v^2}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

There are different ways of demonstrating that proposition, the simplest being as follows: Consider any pair of cross sections of the band at which the motions of the particles are parallel and contrary. Call those cross sections A and B. The weight of band which passes any given cross section in a second is $w\,v$; the particles at A are moving with the velocity $+\,v$, and the particles at B with the equal and contrary velocity $-\,v$; hence, in each second, a mass of matter of the weight $w\,v$ undergoes a change of velocity amounting to $2\,v$; and, according to the second law of motion, the force in units of weight required to produce that change is $\frac{w\,v \times 2\,v}{g} = \frac{2\,w\,v^2}{g}$. One half of that force is supplied by the tension at A, and the other half by the tension at B; therefore the tension at each of those points is $\frac{w\,v^2}{g}$; and the same demonstration may be applied to every pair of points in the band at which the motions are contrary.

Effect on the Band when in Motion.—The effect on the band when in motion is, that at any given point the tension which produces pressure and friction on the pulleys, or *available tension*, as it may be called, is less than the total tension by an amount equal to the centrifugal tension; for this amount is employed in compelling the

* The general law of the centrifugal tension of a band is demonstrated in "Thomson & Tait's Elementary Dynamics" (Oxford, 1868); but it is not applied to questions of practical mechanics, which are foreign to the subject of that treatise.

† See "Transactions of the Royal Society of Edinburgh," Vol. XX, 1850–1851.

particles of the band to circulate in a closed or endless path. It is, of course, to the total tension that the strength of the band is to be adapted; therefore the transverse dimensions of a band for transmitting a given force must be greater for a high than for a low speed.

RULE FOR WEIGHT OF BAND.—One of the most convenient ways of expressing the size of a band is by stating its weight per unit of length—for example, in pounds per running foot, or in kilogrammes per meter. When the size is expressed thus, the corresponding way of expressing the intensity of any stress on the band is in lineal units of itself, such as feet or meters. Let b denote the greatest safe-working tension on a band of a given kind, in units of its own length; w, as before, the weight of an unit of length; so that $w\,l$ is the amount of the safe-working tension in units of weight. Let T be the amount of the available tension required at the driving side of the band for the transmission of power, being usually from two to two and a half times the force to be transmitted. Then the total tension is

$$T + \frac{w\,v^2}{g} = w\,l \quad . \quad . \quad . \quad (2)$$

whence it is obvious that the required weight per unit of length is given by the following formula—

$$w = \frac{T}{l - \frac{v^2}{g}} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For example, suppose that the band is a wire rope—that the greatest working tension is to be equivalent to the weight of 2,900 ft. of the rope, and that it is to run at 100 ft. per second, then we have

$$l = 2900 \text{ ft.};$$
$$\frac{v^2}{g} = 310 \text{ ft.};$$

and consequently the weight per running foot of the rope required is

$$w = \frac{T}{2900 - 310} = \frac{T}{2590};$$

or about one-eighth part heavier than the rope required for a speed so moderate as to make the centrifugal tension unimportant.

In fixing the value of the greatest working tension on a wire rope, a proper deduction must of course be made for the stress produced by the bending of the wires round the pulleys. That stress is given *in equivalent length of rope* by the expression $\frac{L\,d}{D}$ where D is the diameter of the smallest pulley round which the rope passes, d the diameter of the wire of which the rope is made, and L the modulus of elasticity of the wire, *in length of itself*—viz., about 8,000,000 ft. or 2,400,000 meters. That is to say, let l be the length of rope equivalent to the greatest safe-working tension on a straight rope; l, as before, the length equivalent to the actual greatest working tension, then

$$l = l_1 - \frac{L\,d^*}{D} \quad . \quad . \quad . \quad (4)$$

In the case of leathern belts b may be estimated at about 660 ft. or 200 meters.

In the case of a leather belt running at the rate of 100 ft. per second, the weight per unit of length required in order to exert a given available tension is increased in the ratio of $\frac{660}{660-310} = \frac{660}{350}$, or to nearly double, as compared with that of a belt whose centrifugal force is unimportant.

The *sectional area of a leathern belt* may be calculated approximately in square inches by multiplying the weight per running foot by 2.3, or in square millimeters, by multiplying the weight in kilogrammes to the running meter by 1,000.

The ordinary thickness of a single belt being about 0.16 in., or four millimeters, the breadth may be deduced from the sectional area by dividing by that thickness.

The length (L) equivalent to the modulus of elasticity of a leathern belt, as calculated from Bevan's experiments, is about 23,000 ft., or 7,000 meters.

TENSION OF A BAND WHEN AT REST.—It is sometimes requisite to determine the tension which ought to be put upon the two sides of a band when at rest, in order that, when in motion, given tensions may be exerted at the driving and returning sides. The ordinary rule is to make that tension the arithmetical mean between the intended *available tensions* at the driving and returning sides of the band; and when the speed is such that the effect of centrifugal force is unimportant, that rule is sensibly correct.

It is sensibly correct also when the band connects two pulleys that stand a long way apart; for example, in Hirn's system of "Telodynamic Transmission," where the spans between the pulleys, that are connected by means of an endless wire rope, are sometimes 150 meters, or about 500 ft.

On the other hand, when the pulleys con-

* See Reuleaux, *Constructionslehre für Maschinenbau.*

nected by means of a fast-running band are comparatively near together, the tension which should be put upon each side of the band when at rest is nearly equal to the arithmetical mean between the *total tensions* of the two sides of the band when in motion; that is, the centrifugal tension has to be added to the tension given by the preceding rule.

In intermediate cases the tension, when at rest, has values intermediate between those given by the two preceding rules; and when the band connects two pulleys, whose axes are at or near the same level, it is expressed by the following formula, the result of a mathematical investigation, of which it is unnecessary to give the details here. Let l, as before, denote the length of band whose weight is equivalent to the total tension at the driving side when in motion; l' the corresponding length for the returning side; L the length equivalent to the modulus of elasticity; c the *half span*, or half distance between the pulleys; l_0 the length of band whose weight is equivalent to the tension required when at rest. Then, to a degree of approximation sufficient for practice, we have

$$l_0 = \frac{l+l'}{2} - \frac{v^2}{g}\frac{Lc^2}{2}\left\{\frac{1}{3l^2+Lc^2}+\frac{1}{3l'^2+Lc^2}\right\} \quad (5)$$

The two extreme cases, to which the two rules already given apply, are expressed as follows: When $\frac{Lc^2}{3l^2}$ is a very large number, we have l_0 nearly $= \frac{l+l'}{2} - \frac{v^2}{g}$, being the mean between the available tensions of the two sides; and when $\frac{Lc^2}{3l^2}$ is a very small fraction, we have

$$l_0 \text{ nearly} = \frac{l+l'}{2};$$

being the mean between the total tensions of the two sides of the band.

For example, let the band be a wire rope; let $v = 100$ ft. per second; so that $\frac{v^2}{g} = 300$ ft. Let the total and available tensions, when in motion, be as follows:

Driving side, $= 2{,}900$; $l - \frac{v^2}{g} = 2{,}590$

Returning side, $l' = 1{,}605$; $l' - \frac{v^2}{g} = 1{,}295$

Means,

$$\frac{l+l'}{2} = 2{,}252.5; \quad \frac{l+l'}{2} - \frac{v^2}{g} = 1{,}942.5$$

Let $L = 8{,}000{,}000$ ft. of rope, and let the pulleys be 200 ft. apart, so that the half span $c = 100$ ft.; then the required tension at rest is found to be equivalent to the weight of the following length of rope:

$$2{,}252\tfrac{1}{2} - 215 = 2{,}037\tfrac{1}{2} \text{ ft.};$$

being intermediate between the mean of the total tensions and the mean of the available tensions, and somewhat nearer to the latter than to the former.

In order to show, in a general way, how the results expressed by the formulas and the rules are arrived at, it may be stated that the variations of the total tension, when the speed of the band alters, depend upon alterations in its length. When the pulleys are very near each other, the two sides of the band are sensibly straight, and its alterations of length are insensible, so that the total tensions at rest and in motion are sensibly equal, and the centrifugal tension takes effect almost wholly in diminishing the available tension. When, on the other hand, the pulleys are far apart, the two sides of the band hang in the form of curves; the band is free to alter its length to a certain extent; and part of the centrifugal tension takes effect in lengthening the band and increasing the total tension, instead of in diminishing the available tension; and hence the mean total tension is somewhat greater than the tension when at rest, and the available tension is not so much diminished as in a shorter band. If the span between the pulleys is wide enough, nearly the whole of the centrifugal ten ion takes effect in lengthening the band and increasing the total tension; and the mean available tension remains sensibly undiminished.

This accounts for a fact, well known to practical men, that in transmitting a given power between a given pair of pulleys, a long belt is less liable to slip than a short belt.

COAL FROM SEA-WEED.—Some time ago the practice was introduced of converting marine algæ by calcination into an excellent coal superior to ordinary wood charcoal for filtering water, disinfecting sinks, polishing glass and correcting the acidity and decolorizing wines,—also for precipitating and decolorizing vegetable alkaloids.—Until recently no value was attributed to the marine algæ—to-day it is an important article of commerce in several islands.—*Annales du Génie Civil.*

EXPLOSIVE COMPOUNDS FOR PROJECTILES.

From "The Mechanics' Magazine."

Gunpowder, which has been in use for so many years, may now be considered as perfect as it can be made, as regards projectile force and uniformity of combustion. Recent attempts have been made to employ it in a more condensed form, by compressing the charges, but these have failed to a great extent. Of late years, several new explosive compounds have been manufactured as substitutes for gunpowder, and they have, for the most part, been described in our columns. It is claimed for them, generally, that they possess greater cleanliness, almost total absence of smoke, less sensible recoil for a given velocity of projectile, and reduction of danger in manufacture, as being less violently explosive in an unconfined state.—These may be considered as the general claims to superiority of the new explosives. Being principally composed of vegetable fibers nitrogenized, they might aptly be termed explosive fibers. Those now in use are known as gun-cotton, wood-powder, and gun-felt. As a few years' experience only in the production of these compounds can be placed against as many centuries in the production of gunpowder, it is reasonable to expect further progress and improvement in these new substances. When gun-cotton was first discovered, its obvious advantages induced several governments to adopt it in the place of gunpowder. The nature of this substance, however, not being thoroughly understood, many serious accidents resulted from its use. The too rapid combustion injured arms in which it was employed, and it was further found to lack uniformity in firing; in fact, for the most part, gun-cotton was abandoned in disgust. Recently, however, many ingenious methods have been adopted to retard this great rapidity of combustion, and although gun-cotton can be and is used in shot-guns with comparative safety, still it has not yet been produced with sufficient uniformity or slowness of combustion to shoot accurately in rifles. Until this be done, it cannot be considered as a perfect substitute for ordinary gunpowder. Gun-cotton, however, can now be produced in such a condition that it may be stored with safety and without fear of deterioration; and thus prepared, it is largely used for mining and engineering purposes.

Schultze's wood-powder is composed of minute cubes of hard wood, treated in a manner analogous to gun-cotton, and subsequently impregnated with other substances; it is used in a pure state, and requires compressing with considerable force, in order to obtain the best results. It can be fired in rifles, and this is a proof of a certain amount of uniformity, though it occupies a greater volume than gunpowder to give an equal initial velocity to the bullet. Reeves' gun-felt—another comparatively recent invention—is composed of vegetable fibers, which are also treated analogously to gun-cotton, and subsequently impregnated with other materials. This compound is also used in a pure state, and can be fired in rifles. This material was invented and is now being manufactured by Messrs. Reeves & Co., of Glastonbury. It has been found to answer exceedingly well, both in sporting guns and in rifles, but, pending some practical trials which are to be made with this material in a short time, we defer a further reference either to its composition or its special performances. These two last mentioned compounds are made of several different strengths, and the weight of charges used relatively to gunpowder is, of wood-powder, about one-half, and gun felt one-third, *i. e.*, one is three times and the other double as strong as ordinary powder. These new explosives ignite at a much lower temperature than powder, but being composed of less solid matter, the combustion generates less heat, and as many rounds can be fired in a gun or rifle with as much safety as with gunpowder. The fouling is also considerably lessened; the ignition, although quick, does not impart the same sensible recoil. The more solid forms of fiber, such as wood-powder, give more recoil than gun-felt, from which it may be inferred that the elasticity of a compound to a certain extent checks in itself the sudden shock of ignition.

The reduction of recoil in military weapons is of some importance, as it limits the weight and velocity of the bullet. Action and reaction on the bullet and breech of gun may be the same, but when the gases are generated in a gradual manner, the sensible recoil must necessarily be reduced. Even with gunpowder this can be proved by experiment, as quick burning powder will give much greater recoil, with the same initial velocity imparted to the bullet, than a slow burning one. No doubt, the great portion of the motive power exerted by explosives is instantaneous in its action, and ought not to

be generated before it is required to act on the projectile. A gas, doubtless, is elastic according to its density, and, if permanent in this respect (such as steam or compressed air), could not be generated too quickly to give velocity to a projectile. But with all explosives, the reverse has been shown to be desirable, *i. e.*, provided a given charge will consume in a barrel before a bullet quits the muzzle of the arm. The slower the combustion the greater the velocity communicated to the bullet, the friction in the barrel being greatly reducad. Last year, a public trial took place with a view of testing the new explosive substances. Some very fair shooting was made with wood-powder and gun-felt at 100 yards' range in rifles, the latter equalling gunpowder in accuracy, and the former within 30 per cent of it. If there is to be any competition this year, it is to be hoped that it will be at long ranges, that being the true test with rifles, reference being made to the angle of elevation and absolute deviation. As already intimated, some further comparative experiments are to be made with Schultze's wood-powder and Reeves' gun-felt, to which we look forward with interest, and the results of which we shall place before our readers.

UNDULATING AND LEVEL RAILWAYS.

RELATIVE EXPENSES OF TRACTION.

From "Engineering."

A problem often and long discussed by railway engineers abroad is that known as the "equation of gradients;" or, in other words, what additional length of line, taken as level, is represented by given gradients of a given length and inclination? Two lines are, each, 100 miles in length. One, is, we will suppose, a dead level; the other has rising and falling gradients, ascending and descending at rates varying from 1 in 1,000 to 1 in 60. How much longer, not in actual distance, but in respect of working expenses, is the latter than the former? We are in the habit of lumping all railway expenses at so much "per train mile," the train being either passenger or goods, and containing, in the former case, anywhere from 15 to 1,000 passengers, and in the latter, anywhere from 20 to 300 tons of goods. But we are to suppose the same trains over both the lines just assumed. Let the undulating line start with a mile of level, then five miles up of 1 in 1,000, then four miles up 1 in 100, then two miles more up 1 in 80, to a summit 369.6 ft. above the starting point. Let it then run eight miles on a level; then descend at the rate of 1 in 200 for five miles, falling 132 ft.; then five miles of level; then ten miles up 1 in 264, *i. e.*, rising 200 ft.; then five miles up 1 in 132, rising 200 ft. more to a point 637.6 ft. above the base. Let it then have five miles more of 1 in 60, or an additional rise of 440 ft., giving a summit, midway between the termini, 1,077.6 ft. above the starting point. Let the line then descend at the rate of 1 in 200 for five miles, falling 132 ft., then rise for ten miles at the rate of 1 in 400, thus rising again to the summit of 1,077.6 ft. Let it then descend for twenty miles at the rate of 1 in 132, thus falling 800 ft. Let the line fall thence for ten miles at the rate of 1 in 264, the fall being 200 ft., and let the remaining fall of 77.6 ft. take place in the last five miles.

Those who take any interest in the subject will sketch out the profile for themselves; those who do not will turn to another column and read something else.

It will be seen that the line has a maximum gradient of 1 in 60 for five miles in one direction, and a maximum of 1 in 132 for twenty continuous miles in the other. The sum of the ascents from either terminus would be 1,341.6 ft., while the total rise and fall would be, of course, twice as much, both termini being at the same level. Supposing the same trains to be run over the level and the undulating line, how much longer is the latter than the former—not in actual measurement over its various undulations, for that is easily calculable, and in any case very little—but what length of level line could be worked at the same expense? It will require but little consideration to perceive that the question involves many points as to speed, number of stops, position of stations, the preponderance, if any, either way, of the traffic, &c.

Suppose, however, trains of a total weight, including engine, of 100 tons, are to be run through, each way, stopping only midway. The speed on the level line to be 40 miles an hour, requiring $2\frac{1}{2}$ hours running time. The resistance, by Clark's formula, would be 1,735 lbs., corresponding, at 3,520 ft. per minute, to 185 horse power maintained for $2\frac{1}{2}$ hours.

On the undulating line the train, apart from all other resistances, would be lifted 1,341.6 ft. in ascending the various gradients from either end, and if this ascent occupied

an hour and a half, the average work expended upon gravity during that time would be 101 horse power. For

$$\frac{224{,}000 \text{ lbs.} \times 1341.6 \text{ ft.}}{2{,}970{,}000 \text{ ft. lb.}} = 101 \text{ H. P.}$$

The 224,000 lbs. being the weight of the train, and the divisor, 2,970,000, the number of foot pounds in a horse-power, exerted for an hour and a half; corresponding to 33,000 ft. lb. in one minute. If the mean speed of ascent from one end of the line to the half-way summit be $33\frac{1}{3}$ miles an hour, as above assumed in the estimate of an hour and a half, the resistances other than gravity will be

$$8 + \frac{33.3^2}{171} = 14.5 \text{ lb. per ton, or } 1{,}450 \text{ lbs.}$$

for the entire train, at $2{,}933\frac{1}{3}$ ft. per minute, corresponding to 129 horse-power, or, including gravity, to 230 horse-power for an hour and a half, as against 185 horse-power for an hour and a quarter in doing the same distance on a level.

But we now come to the descent, and here it is difficult if not impossible to estimate—not the resistances to motion—but the exact practical effect of descending gradients upon the cost of working. Less fuel and water are of course used, but the actual forces at work upon a train are the same, at a given speed, in descending as in ascending an incline; the difference being merely that gravity takes the place of steam power. If, indeed, as is almost certain to be the case, the speed be greater in going down than up a given incline, on a double line—and supposing the traffic to be equal in both directions—the rails on the down side will, after a time, be invariably found to be more worn than those on the up line, although they are not subjected to the same grinding action from the driving wheels of the engine. Almost the only saving on down gradients is in fuel and water. If no steam be used the cylinders must be kept well lubricated, the attendance or cost of engineman and fireman, is the same, the wear and tear, except upon the fire-box and tubes of the engine, is certainly not less, and if it be necessary to put on the brakes, it is apt to be more. In these respects alone, long down gradients, of considerable inclination, may be taken as involving a working cost equal to that of levels, although, unfortunately, no data are at hand to show that they are neither better nor worse than levels. There are other and considerable items of expense which are wholly independent of gradients.

Regarded, then, as levels, the descending gradients either way from the midway station would require the exertion of 185 horse-power for an hour and a quarter, the ascent requiring 230 horse-power for an hour and a half, thus giving a mean expenditure of $209\frac{1}{2}$ horse-power for $2\frac{3}{4}$ hours on the undulating line, as against 185 horse-power for $2\frac{1}{2}$ hours on the level. Allowing for both the greater horse-power and longer time on the undulating line, it would be $24\frac{1}{2}$ per cent, or, say one-fourth more expensive in working than the level. In other words, the 100 miles of undulating line are practically 110 miles in point of time and $124\frac{1}{2}$ miles in point of cost of working, as compared with the 100 miles of level line. This estimate assumes that the cost of fuel, repairs, wages, &c., are in the exact ration of the horse-power exerted, after adopting the explanation given in respect of descending gradients.

The assumptions which enter into these estimates are by no means conclusive, and they would be greatly affected by the substitution of heavy slow traffic in place of fast passenger traffic. Thus, in the American States, the rule for the "equation of grades" known as Latrobe and Knight's, is to divide the sum of the ascents and descents in feet, by 52.8, and to add the quotient to the length of the line in miles, as the equivalent length of level line. By this rule, the total rise and fall of 2,683.2 ft., in our supposititious line would represent $\frac{2{,}683.2}{52.8} = 50.8$ of additional length, and with a moderately slow goods traffic, this addition would hold good in practice.

There are various aspects of the question of gradients, and different engineers would doubtless take different views of it. But the extra expenditure of power must be as the total rise of the line, and is, in a measure, independent of short, steep and exceptional gradients. With a train of a total weight of 100 tons, any engine with 15 tons of adhesive weight should have no difficulty in dealing with it on a gradient, however long, of 1 in 60; and if the gradient were not above five miles long, occupying ten minutes in the ascent, at the rate of thirty miles an hour, the boiler power required would not be found excessive, supposing the water well up and the pressure high, on entering upon the gradient.

In taking out the cost of working as $24\frac{1}{2}$ per cent more upon the undulating than upon the level line, this represents much more

than the extra fuel used, and more than the extra wages incurred. It represents, perhaps, more properly, the increased cost of lubrication and repairs, including repairs of permanent way. Of the latter, however, a large share is due to climatic and local causes, and is independent both of the resistance of trains and the amount of traffic. A large proportion of the general traffic expenses is wholly independent of the resistance of trains, so that, as affecting dividends, the gradients assumed would not probably diminish the net earnings derivable from a level line by more than 6 per cent, equal perhaps to 1 per cent on the capital of the line.

Compound Steel and Iron Rails.—Mr. Ashcroft has laid a quantity of compound rails on the Charing Cross line. The top member is a Bessemer steel ⊤. The two bottom members are wrought iron angle pieces ⌋ ⌊, bolted together. The rails are said to answer well. Much attention is being directed in this country to the production of a good compound steel and iron rail. The old compound iron rail, with a split head, failed chiefly by the mashing down of the iron into the continuous crack in the head, and the forcing apart of the two members. The compound rail, with a solid head and a split foot, did tolerably good service; the grand defect was the riveting of the two members together so tightly that they could not slip upon each other when expanded by heat. Making the top member of steel and bolting the two together, would undoubtedly make a durable rail. The general plan of Mr. Ashcroft would, however, appear to be better. A modification of this plan is being developed at one of our rail mills.

Steel-headed rails should be cheaper than all steel rails, and they should give nearly all the advantages of steel as far as wearing is concerned. Of course they cannot be so stiff nor so strong as all steel. The use of three, or even of two members, overlapping each other, almost insures against disasters from broken rails. Steel heads welded to iron piles do not possess this advantage, although there is much to be said in their favor. The different plans will be considered at another time. The attention of experts is just now chiefly directed to the production of compound rails with steel heads. Besides immunity against accident from breaking, another great advantage expected from this construction is the permanence of the iron parts. It is believed that the steel heads only will require renewal; and this only after they have worn a dozen times as long as iron heads; and that the iron angle pieces forming the flanges and web of the rail will be practically indestructible. There must, we think, be some wear between the parts thus subjected to abrasion. Nevertheless the economy to be reasonably expected from compound steel and iron rails is very great, and it is probable that railway companies will hasten to avail themselves of the proposed advantages as soon as they are offered.

Coiled Tube Boilers.—It was once thought that the perfection of boiler construction had been arrived at in boilers made on the coiled tubular system. This principle, however, soon showed a radical defect which led to its abandonment. Boilers so constructed failed on account of the tubing becoming red hot when the engine was standing, and the force pump was consequently not acting. This defect, however, has been practically overcome by Mr. Thomas Mills, of England, in an invention described by the London "Mechanics' Magazine." Mr. Mills constructs the fire-box of a boiler, of the upright form, of a coil of tubing enclosed in a case, the fire-box being contained within the coil. The bottom of the coil is connected by a tube brought down outside the casing from the upper part of the boiler, at the lower end of which tube is fixed a self-acting valve placed in a horizontal position, which allows the water to pass on into the coil. The expansion of the water caused by its coming in contact with the heated tubing closes the valve after it has passed through it, and thereby prevents a backward flow of water through the outside tube, and forces the water and steam on through the coil into the upper part of the boiler again. After this, the valve again opens, in consequence of the downward force of the water in the outside tube, thereby creating a perfect circulation through the coil, the discharge end of the coil being brought up inside through the bottom of the upper part of the boiler above the water level. The coil can also be supplied with water by means of a pump worked by the engine (the stroke of the pump being altered according to the quantity of water required to supply the boiler), and cutting off the other supply of water by means of a cock fixed in the outside tube connecting the

upper part of the boiler with the lower end of the coil, thereby feeding the boiler with water through the coil without in the least degree reducing the volume of steam. This method of feeding the coil by the outside tube and valve brings the water direct into the hottest part of the coil, and keeps up a perfect and continuous circulation without the aid of the force pump. This pump is used to feed the boiler through the coil, which is a great advantage in itself, as the cold water does not come into direct contact with steam contained in the upper part of the boiler, which causes loss of steam by condensation. Mr. Mills has made practical trials of this improved system of construction, and finds it to realize the following advantages—economy in every respect, rapid generation of steam, great strength, and almost entire freedom from explosion, together with lightness and simplicity. He states that it raises steam from cold water in less time than any other boiler at present in use. The circulation through the coil being exceedingly rapid, no deposit is found to remain in it. The self-acting valve or clack is so simple in construction that it cannot fail.—*American Railway Times.*

WORKING HEAVY GRADIENTS.

Compiled from a paper before the Institution of Civil Engineers, (Feb. 2, 1869,) by Mr. James R. Mosse, M. I. C. E, on the "Mauritius Railway—Midland Line."

THE GRADIENTS.—The character of the gradients on the Midland line will be understood from the following summary: From Port Louis to the summit there was a rise of 1,817 ft., the distance being about 16 miles, or equal to an average gradient of 1 in 46.68; and from the summit to Mahebourg, a distance of about 19 miles, there was a descent at the rate of 1 in 55.61. For about 12½ miles before reaching the summit the inclination was on an average of 1 in 41.17, and thence for about 13½ miles the line fell on an average 1 in 45.06. The steepest gradient was 1 in 27, of which there was a total length of 13,526 ft., the greatest continuous length of this gradient being 6,163 ft., and the next longest 5,016 ft. The next in severity was 1 in 30, the total length being 9,526 ft., the greatest length of this gradient being 3,000 ft., and several lengths of about 2,000 ft. each. The ascending gradients varied from 1 in 27 to 1 in 60, while the descending gradients towards Mahebourg varied from 1 in 30 to 1 in 60. The curves varied from 950 ft. radius to 6,000 ft. radius, and the lengths of these curves ranged from 200 ft. to 3,200 ft. The ordinary radii were generally from 2,000 ft. to 3,000 ft. The sharpest radius which occurred on the steepest gradients of 1 in 27 and 1 in 30 was 1,600 ft., the greatest continuous length of this curve being 900 ft. on the former gradient, and 1,930 ft. on the latter. The next radius in severity was 2,000 ft. on the maximum gradient of 1 in 27, the greatest continuous length of this curve being 1,000 ft. Reverse curves of this radius 1,920 ft. in length were also found on the maximum inclination of 1 in 27. On descending from the summit to Mahebourg the line from the 17th mile to the 19th mile might be said to be composed wholly of reverse curves, and at the 29th mile the radius was only 1,400 ft., the length of this curve being 1,980 ft., chiefly on a gradient of 1 in 30. Of curves under 2,000 ft. radius there was an aggregate length of 21,165 ft; of those ranging from 2,000 ft. to 4,000 ft. radius there was a length of 49,710 ft.; and of curves from 4,000 ft. to 6,000 ft. (the greatest radius), there was an aggregate length of 25,560 ft., the total length of curves being 96,435 ft., and of the straight portions of the line 89,467 ft.

THE LOCOMOTIVES.—The locomotives furnished under the original contract for working these inclines were seven in number and of the following description: they were tank engines, having cylinders 16 inches in diameter, with a length of stroke of 22 in.; the wheels, six in number, were 3 ft. 6 in. in diameter, and were all coupled, the length of the wheel-base being 15 ft. When supplied with water and fuel these engines weighed nearly 37 tons, and they were worked with a pressure of steam of 120 lbs. per square inch. Subsequently six larger saddle-tank locomotives were designed by Mr. Hawkshaw, having the following dimensions: cylinders 18 in. in diameter, with a length of stroke of 24 in.; the wheels, eight in number, were 4 ft. in diameter, and were all coupled, the length of the wheel-base being 15 ft. 6 in. When supplied with water and fuel, these engines weighed nearly 48 tons, and they were worked with a pressure of steam of 120 lbs. per square inch. The center pairs of wheels (one of which was the driving pair) were fixed stiff on the frame; but in order to pass easily round the curves, both the leading and the trailing

wheels had three-quarter inch play on each journal, and the joints of the coupling rods, connecting these wheels with the driving pair, were fitted with a ball and socket, so as to allow the requisite motion. All the engines were manufactured by Messrs. Sharp, Stewart & Co., and worked very satisfactorily. These engines would, with passenger trains, take five carriages and one brake-van, equal to a load of 42 tons, though on some occasions they had hauled eight loaded vehicles, weighing in all about 56 tons; while with goods trains the usual load with the lighter locomotives was 70 tons, and with the heavier locomotives from 100 tons to 120 tons. It should, however, be stated that by reducing the lead of the slide valves to one-eighth of an inch, the power of these engines had recently been increased 10 per cent.

Speed and Duty.—The average speed of the passenger trains, including stoppages, was 12 miles per hour between Port Louis and the summit, and 15 miles per hour from Mahebourg to the summit; while that of the goods trains was about 9 miles an hour, including frequent stoppages. The particulars of a trip made on the 12th December, 1867, when the fuel and water were noted more accurately than usual, were given in detail. From these it appeared that the train consisted of ten loaded wagons weighing together 83 tons, or with the engine a gross load of 131 tons; the average speed from Port Louis to the summit was 11 miles per hour, and taking the average pressure of steam in the cylinder as 60 lbs per square inch, the power exerted would be $\frac{131\times60\times11\times88}{33{,}000}$ = 230 H. P. or, not including the weight of the engine, 146 H. P., and this, divided by the weight of the locomotive, was equal to 3.04 H. P. per ton of motor. The coal used on the above trip was obtained from Sydney, N. S. W., and the consumption amounted to 4.75 lbs. per H. P. per hour, 8 lbs. of water being evaporated by 1 lb. of coal, but ordinarily only 7½ lbs. of water were evaporated by 1 lb. of this coal.

Carriages and Brakes.—With the exception of the first-class carriages all the others on this railway had a brake on every wheel, worked from the inside. The ordinary passenger trains were composed of one first, one second, and two third-class carriages, with one brake-van, and to these trains Mr. Clark's continuous brake was attached. This apparatus was worked by a chain, which tightened the brakes on every one of the wheels simultaneously. The brakes were taken off by heavy counter-balance weights, resting longitudinally over the chain in the center of the carriage, between the front and end wheels. This apparatus was sufficiently powerful to lock every wheel, and had worked satisfactorily; for during two years there had not been a single fracture of the chain, nor of any of the working parts. It, however, required careful management, and must be applied gradually, before the train had acquired serious momentum. The brake-van of every passenger train was now provided with sand boxes leading to the rails, as formerly the dew on the rails wetted the wheels of the brake-van, and prevented the friction rollers of the apparatus from revolving; whereas, as soon as sand was applied, the wheels became dry, and the friction rollers acted efficiently. Every train of four or five carriages had two guards, one to work the continuous brake, the other to use the separate brake, if necessary, attached to that carriage which was not connected with the continuous brake. The heaviest passenger train which had descended from the summit to Port Louis consisted of fourteen carriages and two brake-vans, conveying five hundred and thirteen troops. That was on the 14th November, 1868, and it was kept perfectly under control by the continuous brake on four carriages, and by five additional brakesmen, the speed being steadily maintained at 20 miles per hour. There were but four instances of passenger trains getting for a time beyond control: first, one morning when the rails were wet, a train descended from the summit for a distance of 3¾ miles in five minutes, or at a speed of 45 miles per hour. This was the highest speed on record, and it occurred before the sand boxes were put on the brake-vans. Secondly, in a similar way, another train attained a speed of 32 miles per hour. Thirdly, a train overran a station for a considerable distance, chiefly from the want of sufficient care on the part of the engine driver and guards. Lastly, a train once attained an excessive speed in descending from the summit, through the dropping off of the nut of the eyebolt passing through the axle on which the continuous chain of the brake apparatus was wound. The speed in descending the inclines was limited theoretically to 18 miles per hour, practically it rarely exceeded 25 miles, and the carriage

brakes were generally sufficient to control the train, without the necessity of applying the engine-brake. The goods trains in descending the inclines as a rule consisted of eight loaded wagons with the lighter locomotives, and of ten or twelve wagons with the heavier engines; and in these cases also the brakes on the wagons, two being screw brakes, and the remaining wagons being furnished with the ordinary lever brakes, afforded power sufficient to control the trains. It had long been in contemplation to make safety sidings at the foot of the steepest inclines, but the ground was by no means favorable for the purpose, and, moreover, it was feared that such sidings might become a source of danger.

Cost of Working.—The rules in force for the regulation of the traffic on the main line and at the stations were then given in detail, as well as the traffic returns for the years 1866 and 1867, the rates for passengers and goods, and the statement of the receipts and expenditure for the year 1866, from which latter it appeared that the working expenses were then 62½ per cent of the receipts; but this result was said to be due to several exceptional causes. Considering the high price paid for skilled labor and for fuel, the agricultural character of the district through which the line passed, the severity of the gradients, the want of anything that could be called a town save at Port Louis, the lack of minerals or manufactures to transport, the peculiar nature of the sugar traffic—requiring a large amount of rolling stock for three months in the year, whereas for the remaining nine months less than half the quantity sufficed—the author thought it was not surprising that the working expenses of the Midland line should in 1866 have been 62½ per cent of the receipts, or 5s. 5d. per train mile. Now that the heavier locomotives enabled a larger amount of sugar to be carried, and when the goods traffic was further developed, it was believed a considerable decrease in the percentage of working expenses to receipts would ensue, accompanied also, it was hoped, by a reduction in the cost per train mile.

Conclusions.—In conclusion it was remarked, that although it might sometimes be impossible to construct a railway with easier gradients than those on the Midland line, yet the difficulty of working these inclines in wet weather had been so great, the load hauled so small, and the speed so low, that the author thought the severity of any gradient for a long rise should never exceed 1 in 40; and that it would always be preferable (under the ordinary system of tractive power), to incur, within reasonable limits, any additional expense that might be requisite to bring the inclination within this ratio. It was also suggested that in laying out such inclines, whatever might be the ruling gradient (provided it was not entirely exceptional, and where additional power could be applied), that gradient should be followed throughout the line, as far as the features of the country would permit. It was likewise recommended, that pieces of level should be introduced between the different inclinations, as they were of the greatest value, in controlling the trains in descending. The Midland line had now been opened for more than three years, and fortunately no accident had yet occurred to any train in descending the inclines.

SUBMARINE ENGINEERING.

SINKING BRICK AND IRON PIERS—SAND PUMP—NEW EXCAVATOR.

From a paper by Mr. Imrie Bell, M. I. C. E., "On sinking wells for the foundations of Piers and of the Bridge over the River Juma, Delhi Railway," and a paper by Mr. John Milroy, Assoc. I. C. E., entitled "Description of Apparatus for Excavating the interior of and for sinking Iron Cylinders," before the Institution of Civil Engineers, March 2d, 1869.

Sinking Brick Piers.—The mode of forming the foundations of the bridge over the river Juma, was thus described by Mr. Bell: It appeared that the bed of the river at this point consisted of coarse and fine gravel and sand, interspersed with layers of blue clay 3 ft. and 4 ft. thick, and covered with silt; but during the rainy season large boulders, weighing 14 lb. each and upwards, were brought down and deposited by the scour of the river 30 ft. below the level of the bed. The bridge comprised twenty-four openings, each 99 ft. in the clear, and the superstructure was composed of two lines of lattice girders, resting on brick columns or wells, each 12 ft. 6 in. external diameter, and 5 ft. 10 in. internal diameter, so that the wall of the well was 3 ft. 4 in. thick. In some instances the sites of the piers were got clear of water by diverting the river at different points during the dry season, while in other cases islands were formed, by driving a half circle of piles on the up-stream side, then lowering sand-bags on the down stream side, to the height of 4 ft. or 5 ft.,

and afterwards filling up with sand to 5 ft. above low water. The curb on which the steening of the well rested was formed of wrought-iron plates and angle irons riveted together; and in cross section the curb was like an inverted right-angle triangle, of which the height was 4 ft. and the base 3 ft. 4 in. When each curb was complete it was moved into position, and the compartments were then filled in with concrete. The curb was next sunk by men working with the "phaora" (spade) and basket, till the upper edge was within 3 in. of the level of the water, when a ring of brick work was carried up for a height of 6 ft. The excavation of the interior was again proceeded with by means of the "jham" and divers in the old native style; afterwards a further height of 10 ft. of brick work was added, but the material was now removed by a sand-pump (to be hereafter described) worked by a steam hoist of 4-horse power, as was the case after two additional lengths, each of 15 ft., were built, when the well was carried down to its full depth. In operations of this nature great care was necessary, especially at first, to insure the well or cylinder descending vertically. For this purpose the curb should invariably be sunk alone without any building. The first height of brick work should not exceed 5 ft. or 6 ft., the next 10 ft., and it was never advisable to build more than 15 ft. at a time. Before commencing any additional height the top course of the brick work already built ought to be removed, to insure a thoroughly clean surface for the mortar.

Lime and Mortar.—The lime used at the works was made from marl or, more properly, calcareous clay, which, while soft, was roughly moulded into bricks. These were stacked to dry for three or four days, and were afterwards burned with wood in kilns for fifty or sixty hours. The flues were then closed with bricks and mud, and so allowed to remain for two or three days. On the kiln being opened the lime bricks were unloaded almost in a whole state, were ground under stones, screened, and carried to the works pure and free from ash or dirt. The mortar was made from one part of ground lime and one part of clear, sharp sand. This mortar was used in all the well foundations of the bridge up to the level of low water; and as a proof of its quality it was stated that it was easier to break the work as a mass than to separate it at the joints or beds. Above the level of low water the mortar was composed of white hill lime, and sorkhee, or crushed brickbats, in equal proportions, as it was found that the lime from the calcareous clay lost the greater part of its cohesion when used in work exposed to the vicissitudes of the atmosphere—whether this arose from the frequent changes from dryness to humidity, or from heat to cold, was not ascertained.

Time Occupied.—The well sinking for the foundations of the piers and the abutments of this bridge was completed in little more than two years, which, without deducting any time for building up the brick work, or for that unavoidably lost by the rise in the river during rains, gave an average rate of 159 ft. per month. The time occupied in the building of the steining of the wells, erecting, taking down, and reërecting scaffolding and staging for sand-pump, weighting the wells, &c., was equal to that employed in sinking. This would give the rate of sinking as a little over 300 ft. per month. If cast-iron cylinders had been used, the work could have been performed much more quickly, as the portions of the cylinders could have been put together more rapidly, and owing to the slight bearing surface exposed by the thickness of the iron, compared to the breadth of the brick work in the walls of the well. The total weight of the foundations and of the iron girder superstructure on each well was 420 tons, and the area of the bottom of each well was 117 ft., so that the weight was less than 4 tons per square foot.

The Sand Pump.—The novelty in the sinking of the wells of this bridge was in the use of the sand pump. This was described to consist of a wrought-iron cylinder having a pump riveted to it at the top, in which was a piston fitting loosely, and pierced with small holes to allow of the escape of water. The piston rod terminated in an eye at the upper end, to which a chain could be attached. The bottom of the cylinder was movable, and in the center there was an upright suction pipe, projecting outwards for a distance equal to its own diameter, and inwards nearly to the top of the cylinder. When the pump was lowered to the bottom of the well, the chain attached to the piston rod was worked up and down like a ringing engine. In this way water was first drawn through the upright pipe, followed by sand or other material, which fell over the pipe into the cylinder. This operation was continued until the cylinder was quite full,

which was known by the piston working stiffly, when the machine was raised to the surface; the bottom of the cylinder was then detached, with the column of sand resting on it, and another cylinder bottom which had been cleared of its sand was substituted. The number of men employed at each well was fourteen, nine working the chain, two clearing away the stuff brought up by the pump, one in charge of a steam hoist, one breaking firewood, and an overseer. The average rate of sinking, including contingencies, was about 6 ft. in eight hours. This rate was extraordinary when compared with the old system of the "jham" and diver, and would, it was believed, materially reduce the expense of bridge work in India.

MILROY'S EXCAVATING APPARATUS.—Mr. Milroy believed that for the purpose of sinking cylinders, the great desideratum hitherto had been some method of excavating the earth from the interior without at the same time having to take out the water, and to keep it out during the operations. This object seemed to the author to have been attained by a machine of his invention, which was used in the construction of the bridge over the river Clyde, for the Glasgow (City) Union Railway, to which Mr. Fowler and Mr. Blair were the engineers.

The excavating apparatus, commonly called the "excavator," was thus described: It consisted of a horizontal frame of iron, with an outside rim 9 in. in height, to which radiated, like the spokes of a wheel, T-irons from a small cast-iron ring in the center. To the bottom of the outside rim were hinged eight heavy iron spades, which, when drawn in, fitted closely, with their points pressing against the inner ring. The hinges of the spades were so constructed as to prevent them from turning back beyond the perpendicular. The whole apparatus was very strongly made, and it formed, when closed, a nearly water-tight tray. When the machine was descending the spades were allowed to hang vertically, and they were forced into the ground by the aid of two chains fastened to the top of upright arms on opposite sides of the excavator, then passed down the cylinder, under a pulley, up between two leaders, and over another pulley, the end of each chain being wound round the large axle of the capstan, or drum, on the landing stage. These chains were calculated, when tightened, to keep the machine down, whilst the spades were being drawn in through the crowd, and up to the frame. This was effected by a second set of chains, all of equal length, and each fastened at one end to the inside of a spade, and at the other end to the end of a main chain, by which the machine was raised to the surface, with the earth it contained, by means of a steam hoist. In order to enable an opinion to be formed of the capabilities of the excavator, it was mentioned that the progress of the excavation, and the corresponding subsidence of the cylinder, reached from about 12 ft. to 20 ft. per day of ten hours, inclusive of the time employed in adding fresh lengths of cylinder, putting on weights, &c. When there had been little interruption for any of these purposes, it had amounted to 25 ft. in the ten hours, and then the average quantity of sand brought up at each lift was 21 cubic feet, and the total quantity during the day was found, by measurement, to be 70 cubic yards. Twelve men in all were employed, viz: one engineer, one stoker, six men working the drums, three attending to the loading and discharging of the excavator, and one man wheeling away the materials.

In conclusion, the following advantages were claimed for this apparatus: First, that it was perfectly independent of water, which was allowed to remain in the pit or cylinder until the excavation was completed; secondly, that it could be used, and was equally effective, at any depth, without sensible difference in the cost of working; thirdly, that its rate, both of sinking and of excavating, was higher than had yet been attained by any other method; and lastly, that it was not liable to get out of order, whilst its action was always in the same perpendicular line, and the expense attending its working was comparatively trifling, as skilled workmen were not required.

CHIMNEY SWEEPING "ENGINEERING" IN AMSTERDAM.—There has recently been formed in Amsterdam, with the Royal approbation, a nondescript association with the title, "*Amsterdam Soot Company.*" The director has the title, "Royal Chimney Engineer;" the managing agent is a distinguished advocate of that city, and the commissioners designated by the government are, an inspector of public works, a great diamond merchant, already president of one industrial association, and an architectural engineer, who is also a manufacturer. The company has for its business the sweeping of chimneys and trade in soot.—*Annales du Génie Civil.*

TEN-WHEELED FREIGHT ENGINE—PENNSYLVANIA RAILWAY.—One of these engines, as designed by Mr. J. B. Collins, Mechanical Engineer to the Company, is fully illustrated in "Engineering," March 5th. The intention in the design was to embody all improvements developed by experience, and to omit all superfluities of construction. In the finish of the engines there is no attempt at ornamentation; there are no brass bands about the boiler, and there are no brass accessories, except the bell and whistle. The painting is plain, and no scroll-work or pictures are introduced. The object sought, in fact, has been to make a plain serviceable engine, without any unnecessary ornamentation. The principal dimensions are as follows:

	ft.	in.
Cylinders.		
Diameter	1	6
Stroke	1	10
Distance apart from center to center	6	9
Length of ports	1	4
Width of steam ports	0	1¼
Width of exhaust ports	0	2¼
Width of bars	0	1
Distance from center of cylinder to valve face	1	3⅝
Lap of valves	0	0¾
Travel of valves in full gear	0	5
Wheels.		
Diameter of coupled wheels	4	7
Diameter of bogie wheels	2	4
Distance between center of bogie wheels	5	8
Distance from center of bogie to center of 1st pair of coupled wheels	8	5
Distance between centers of 1st and 2d pairs of coupled wheels	5	0
Distance between centers of 2d and 3d pairs of coupled wheels	7	5
Total wheel base	23	8
Boiler.		
Diameter of barrel outside largest plate	4	2
Length of barrel	11	11
Length of fire box casing	5	9¼

The four-wheeled bogie under the front end of the engine is of the ordinary pattern, with a swing beam, and the front pair of coupled wheels has tyres without flanges. The bogie is fitted with the usual chilled disc wheels, and the coupled wheels are of cast-iron with hollow spokes and rim. The connecting rods take hold of the crank pins on the center pair of coupled wheels, and the eccentric rods are cranked so as to pass respectively above and below the front pair of coupled wheels to the links. The valve faces are situated above the cylinders, and the valves are worked through the intervention of rocking shafts, as is usual in American engines.

LIGHT RAILWAY ROLLING STOCK.

From "The Engineer."

That railways do not pay a fair profit on the sums invested in their construction is a truth fully recognized by the modern capitalist. This truth, so important in its bearing on the development of the resources of the country, has been carefully investigated by engineers and financialists alike, and, as a result of this investigation, two general propositions have been laid down. The first is, that very large sums have been in some cases necessarily, in other cases unnecessarily, wasted in unproductive work, such as law expenses, the construction of palatial termini, the reduction of lines to a dead, or nearly dead level, by embankments and cuttings, etc.; the second proposition is, that railways do not pay because they are worked on too expensive a system. If we may be allowed the expression, according to one party the statics of our railway system are to blame; according to the other the dynamics of that system are in fault. It forms no part of our purpose now to investigate questions relating to the statics of the railway system. The railways are there, with all their faults or excellencies, and cannot be altered. We must make the best of them. We propose here to consider the bearing of some of the questions connected with the dynamics of railways, that is to say, the system on which passengers and light goods are conveyed from place to place; but we wish it to be particularly understood that nothing which we may advance in favor of the use of light engines is intended to apply to the working of heavy goods or mineral trains. These can only be hauled by engines of great power; and the heaviest goods locomotives bear a comparatively reasonable proportion to the weight of the loads drawn by them—a condition favorable to economy, which has no existence in the case of passenger and other light traffic.

We are indebted to Capt. Huish's "Reports on Railway Plant," for the following statements as to the augmentation in the weight of railway rolling stock, which took place between 1831, the date at which the reports commenced, and 1848. The reports refer to what is now known as the London and North-Western system. In 1831 the average weight of the engines on the Liverpool and Manchester, and London and Birmingham Railways, was seven tons. In 1848 it was more than twice as much, being

18 tons 13 cwt. The heaviest engine in use on these lines, in the first mentioned year, was seven tons; in 1848 it was 37 tons. The weight of the carriages increased in the same period from a maximum of 3 tons 10 cwt. to 4 tons 6 cwt., and the average speed of the passenger trains had increased from 17 miles per hour to 30 miles per hour. What took place on the North-Western system accurately shows what took place through the length and breadth of the kingdom—*ex uno disce omnes*. There is not, so far as we are aware, any compendious statement in existence which will show the amount of augmentation between 1848 and 1868, but there is good reason to believe that it is very considerable. Engines weighing less than 20 tons full, are now the exception; and the average weight of all the engines working important lines in England must exceed 23 tons. The weight of carriages has also gone up, 5, 7, and even 9 tons being no uncommon weight for ordinary carriages, while on the Metropolitan Railway, carriages are used which weigh 16 tons. It does not appear that the carrying capacity of these carriages has undergone a corresponding increase. Additional strength, especially in the under frames, has been introduced, because heavy engines knock light carriages to pieces; but it does not appear that any other very valid reason for the increase of weight has been adduced, save perhaps one, viz., the modern carriages are rather more roomy and commodious than those used 20 years ago.

There is no room to doubt that the dead weight of engines was first increased in order to get more power; and had it been possible to work these heavier engines with carriages of the same weight as those employed in the earlier days of the railway system, all might have been well; twenty tons or so would have remained about the weight of the heaviest class of locomotives employed in conveying passengers; but the increased dimensions of the engines rendered a corresponding increase in the strength and weight of the vehicles drawn a necessity. The augmentation reacted on the engines, and so weight increased daily and hourly, till a new element was introduced which rendered further augmentation all but an impossibility. This new element was the stability of the permanent way. The roads could not sustain heavier loads, and therefore heavier loads were not put on them. It must not be forgotten that at one time there was a species of mania among locomotive superintendents for big engines. It was, in the first place, a very pleasant thing to be able to boast that you had bigger engines than your neighbors, just as it is a pleasant thing to have the fattest ox at a show, or the finest house in a street. In the second place, it was pleasant to know that when you stood on the foot-plate, you had beneath you a machine capable of whisking the train behind it at almost any pace you pleased. Big engines were, in a sense, luxuries, and they were paid for at a price which railway companies could not afford. Probably the first blow that the big engine craze ever received was the failure of the "Liverpool," on the London and North-Western Railway. This engine was built by Mr. Crampton, especially to compete with the large engines which Brunel, who idolized the Big, patronized on the Great Western. The "Liverpool" had 18 in. cylinders, 24 in. stroke, 2,290 ft. of heating surface, two 8 ft. driving wheels, six 4 ft. carrying wheels, an 18 ft. 6 in. wheel base, and weighed full 35 tons. The tender weighed 21 tons. Total weight, 56 tons. After working the express traffic between London and Wolverton for some time, it was found that the permanent way began to give out, and so the engine was withdrawn from active service.

After enduring for many years, the passion for large and heavy engines appears to be dying out; and engineers who not long ago regarded heavy engines as the *summum bonum* of locomotive superintendial happiness, are now quite prepared to listen to reason, to investigate patiently, and even to believe that it may be quite possible to work, if not all, still a considerable portion of the ordinary passenger traffic of our railways on a system which completely ignores heavy engines and heavy rolling stock. There is not wanting evidence that a species of revulsion of feeling is setting in, and not the least hopeful symptom is that already we hear rumors of the formation of a company, having on its board of direction some of the ablest engineers of the day, and specially called into existence to test cautiously and tentatively the merits, advantages, and disadvantages of the light rolling-stock system. What this system is we propose to tell such of our readers as are not familiar with its characteristics; and we shall further add some facts, now matters of history, which will show that the prospects of success are enormous; so enormous that we

cannot account for the neglect of the system during past years on any other hypothesis than the existence of an all but universal mania for big engines, to which we have already alluded.

According to the advocates of the light rolling stock system, heavy engines are required only because the trains are heavy. Keep down train weight, and engine weight is decreased as a matter of course. This object they propose to effect by the use of combined carriages and engines. Whether this arrangement is or is not the best that can be adopted, we are not about to decide. It illustrates very clearly the principles of the light rolling stock system, and, in so far it answers our purpose at the moment. We shall have something to say to its mechanical fitness for the intended purpose hereafter. In this arrangement the weight of the engine is very small comparatively, and the load it is to haul is also light. It is urged against light engines that they lack adhesion. Quite so; but adhesion is a comparative term after all. That one of the new engines will not possess enough adhesion to haul a 300 ton train is quite true: but it is not wanted to haul 300 ton trains, or even 100 ton trains; and if it can be shown that it possesses adhesion enough to haul the greatest load which it is intended to haul, then it has adhesion enough. Now by making some of the wheels of the vehicle as a whole, not only carry all the engine, but a part of the load as well, it is apparent that the engine must be better off for adhesion, *cæteris paribus*, than any ordinary tender engine—better off, indeed, than any tank engine. There is no room whatever to doubt that the proposed carriage will do what it professes to do, at least so far as adhesion is concerned.

The entire weight of a combined passenger carriage and engine need not exceed sixteen tons, to convey 90 passengers, weighing six and a half tons. There is not at this moment a railway in the kingdom conveying the same number of passengers which does not put in motion a dead weight of 34 tons, or more than double that of the combined carriage. In one case 2.461 tons of dead weight are employed in the conveyance of each ton of passengers; in the other, the dead weight is to the paying load as 5.23 to one. Nor is this all. The sixteen tons of the combined carriage may be, and should be, carried on eight wheels, and no pair of wheels should carry more than five tons. If an ordinary locomotive is used, the smallest weight on at least two pairs of wheels must be double that on the two pairs drawing the combined carriage, for as the load is more than double, the adhesion must be more than double, and the adhesion is as the weight—unless, indeed, the locomotive is to have less adhesion than the combined carriage. And if it is admitted that it can do with less, then the argument that the combined carriage will not have adhesion enough falls to the ground. But it may be shown that the injury done to permanent way will be as great by one pair of heavily loaded wheels as by four or five pairs—that is to say, if in a train 100 wheels are loaded with but two tons each, while the single drivers of the engine are loaded with five tons each, then the road must be strong enough to carry not the light but the heavy load. It follows that rails weighing 45 lb. to the yard would carry the combined engine and carriages as well as 60 lb. or 70 lb. would carry trains worked on the ordinary system. Or that if existing track is retained, it will, if the rails are of good quality, cost little or nothing in repairs, the road being practically indestructible under the assumed conditions of load. It follows, therefore, that the expense of road maintenance may be enormously reduced by the adoption of the combined system. We shall show in a moment how great a saving may be effected in running expenses.

"But," it will be urged, no doubt, "if the light system is so good, why has it not come into use long since?" Now, on this point we are not prepared to speak fully. We believe we may go so far, however, as to say that its non-adoption has resulted from causes which have had nothing to do with questions of mechanical science, and we shall not further refer to them. The best answer that can be brought to all cavilers lies in facts, and we shall, for convenience, first sum up all the objections which, so far as we are aware, have been brought against the combined carriage system, and then proceed to consider them in connection with facts.

1st. Steam carriages must lack adhesion.

2d. They must be slow, because their boilers must be small.

3d. They cannot be competent to deal with exceptional traffic, as, for instance, on market days in country districts.

Now, it so happens that every one of these points was raised and settled long

since. It is a great mistake to suppose that we have been theorizing all this while; on the contrary, every statement we have made in favor of the light rolling stock system, and the whole purport of this article, is borne out by the practical results obtained from the actual use of combined carriages and engines years ago.

Some twenty years ago Mr. Gregory had a combined carriage and engine from Mr. W. B. Adams to work the Tiverton branch of the Bristol and Exeter Railway. This steam carriage was christened the Fairfield. The machinery and carriage body were on one frame, 40 ft. over all, hung on six wheels; the two leading wheels, 4 ft. 6 in. in diameter, being the drivers. The wheel base was 28 ft. long, and peculiar provisions were introduced to let the machine get round curves. The cylinders were 8 in. diameter, 12 in. stroke. The boiler, of the ordinary type, was 7 ft. 7 in. long in the barrel, and 2 ft. 6 in. diameter. It contained 115 tubes 1¼ in. by 8 ft. The fire-box was 2 ft. 6 in. long by 2 ft. 3 in. wide, by 4 ft. high. The heating surface in the box was 37 ft., in the tubes 325 ft. The carriage carried fifty-eight passengers.

Now let us see how far the performance of this steam carriage justified the objections urged against the system. First as regards want of adhesion. We find that the Tiverton branch was five miles long, and had a gradient of 1 in 86; the fact that this was regularly worked in all weathers, is proof that the adhesion was sufficient. Next, as to speed. The Fairfield ran from Exeter to Bristol, 76 miles, with an extra load behind her weighing ten tons, equal, say, to 140 passengers in all, in three hours 37 minutes. Of this time 58 minutes were spent stopping at twelve stations, leaving her regular pace 28 miles an hour. The maximum speed attained on this trip was 47 miles an hour. So much for speed. Now for capacity. The Fairfield took as much as 31 tons—that is to say, three other carriages loaded, up the Tiverton gradient of 1 in 86, doing the five miles in eleven minutes, or at the rate of 27 miles per hour. This surely demonstrates the practicability of attaching more carriages when necessary, and therefore of rendering steam carriages quite competent to the discharge of abnormal duties. The consumption of fuel on regular work was 8.7 lb. of coke per mile. After working the Tiverton branch for some time the Fairfield was put on the line from Clevedon to Yatton; on this road her regular speed was 24 miles per hour, she ran sixteen trips, or 64 miles per day, and used, in doing so, 397½ gallons of water, and the total cost of running, exclusive of repairs, was but 3½d. per mile.

The results obtained from the Fairfield were eminently satisfactory—satisfactory enough, we think, to justify the favorable opinions we have expressed regarding the system; but we have still more conclusive evidence to urge in its favor. Mr. Samuels designed a carriage built by Mr. Adams, and called the Enfield, which was put to work on the Great Eastern Railway. We are indebted for the following facts relating to the Enfield to a paper read by Mr. Samuels before the Institution of Mechanical Engineers:

The Enfield had 8 in. cylinders and 12 in. stroke; driving wheels 5 ft. diameter; distance between centers, 20 ft.; width of framing, 8 ft. 6 in. The boiler was of the ordinary locomotive construction, 5 ft. long by 2 ft. 6 in. diameter. The fire box was 2 ft. 10½ in. by 2 ft. 6 in. There were 115 tubes of 1½ in. diameter, and 5 ft. 3 in. in length, giving a total of 230 ft. heating surface in the tube. The area of the fire box was 25 ft., giving a total heating surface of 255 ft. The weight of this steam carriage was 15 tons 7 cwt. in working trim. The engine and carriage being combined, it is evident that the weight on the driving wheels was increased by the load carried, and that this weight increased in the same ratio as the load required to be taken. The extreme distance between the centers of the leading and trailing wheels being 20 ft., accounts for the steadiness of this machine; there was, indeed, no perceptible oscillation when traveling at the highest speed, and this verifies the observation, "that the steadiness of an engine depends not on the position of the driving wheel, but upon the length of the rectangle covered by the wheels." This engine, at the same time, daily traversed curves of five or six chains radius. The Enfield steam carriage was originally intended to convey 84 passengers, but as it was found that when she was put on as an express train the passengers increased in number, a North Woolwich carriage was attached capable of conveying 116 passengers, and also a guard's brake-van, making provision altogether for 150 passengers, which was her regular train, taken at a speed of 37 miles per hour.

The following return shows the miles run and coke consumed by this engine during the seven and a half months' regular working, from January 29th to Sept. 9th, 1849:

Total miles run.	14,021
Hours, running time	705
Hours, standing time	1,457
Total hours in steam	2,162
Cwt. of coke consumed in running	743
Cwt. of coke consumed in standing	408
Cwt. of coke consumed in getting up steam,	286
Total cwt. of coke consumed	1,437
Pounds per mile ave. consumption of coke,	11.48

The Enfield was in steam fifteen hours per day, the fire being lighted about six in the morning and drawn at ten o'clock at night. But of these fifteen hours it appears, by the return, that she was engaged running only five hours, the remaining ten being employed standing in the siding. It was found by experiment that the quantity of coke consumed standing was 32 lb. per hour; and after deducting this and the quantity consumed getting up steam, it will appear that the actual consumption of coke running was under six pounds per mile. It must also be particularly borne in mind that this consumption of coke included the total goods and coal traffic on the branch, amounting to 1,410 tons, viz., 169 tons of goods and 1,241 tons of coal. The Enfield steam carriage worked the 10 A. M. passenger train from London to Ely, on 14th June, 1849, a distance of 72 miles, taking behind her three of the ordinary carriages and two horse-boxes; she arrived at Ely eight minutes before time, and the total consumption of fuel, including the getting up steam, was found to be $8\frac{3}{4}$ lb. per mile. The tubes of the boiler were only 5 ft. 3 in. in length, and the economy of fuel is consequently scarcely at the maximum. Mr. Gregory expressed, in the paper in question, as the result of his experience, the conviction that, for express purposes, and for the larger portion of the branch traffic on railways, the light steam carriage is the best adapted and most economical machine, both as to first cost, compared with the work done, and in working expenses. The repairs of the permanent way were also very much reduced, as may be easily imagined. On the Eastern Counties Railway, in 1849, an engine and tender of, say, 30 tons, a brake-van, a first-class carriage, and three third-class carriages, conveying 120 passengers, made a total weight of 59 tons, and the consumption of coke was, on the average, 34 lb. per mile. A steam carriage weighing only seventeen tons will transport the same number of passengers at from 7 lb. to 8 lb. per mile when the best proportions are attained.

It is unnecessary, we think, to prolong this article by adding further arguments in favor of the light rolling stock system. We shall, in another impression, consider the nature of the mechanical problems to be solved by the designers of steam railway carriages, and the best methods of solution.

STEEL HEADED RAILS.

In 1866 Messrs. John A. Griswold & Co., of Troy, sent 500 tons of steel headed rails, in lots of 10 to 100 tons, to some dozen different railway companies. The steel surface was about $\frac{5}{8}$ in. thick when finished; the rail was a pear-headed 56 lb. pattern, the stem being, as it proved, too light for very heavy engines. Under a yielding iron head, the web had proved strong enough. Under the very heavy engines of the New York Central and Michigan Southern, some of these rails failed in the stem, but the heads rarely became loosened. The wear was, however, in the worst cases, very much better than of iron, and the greater number of the rails are still in use on these lines, although placed where they endure constant switching and unusual wear. On some lines, where the machinery is somewhat lighter, these rails are all in excellent condition. Some on the Hudson River road, between Albany and Troy, show hardly any deterioration. The report of the Eastern Railway (Mass.), for 1868, says of them: "We have had 25 tons of iron rails with steel heads, in use as an experiment, in our main track for upwards of two years, and so far with the most satisfactory results." The Superintendent of the Boston and Providence Railroad, says of some of the same lot of rails: "I take pleasure in saying that a lot of steel-headed rails, furnished by John A. Griswold & Co., in 1866, are wearing equal to the best English (steel) rails; indeed there is no difference. These rails are laid on one of the most exposed places on this road." On the whole, this steel-headed rail has proved itself equal to about three of the best iron rails.

The heads of these rails were made from some of the first Bessemer steel produced

at Troy, and were rolled into slabs deeply grooved on the under side, where they were to be joined to the iron pile. The weld, or the weld and the dovetail together, made a much more perfect union between the head and the rest of the rail, than is usually made in iron. The three years practical test, and numerous tests by the trip-hammer, have shown the union to be sufficient, and nearly uniform for the whole lot. With a heavy, strong iron body, such steel-headed rails should wear, for some years, as well as all steel, but of course they would not be as stiff, and when the head was worn very thin, it would doubtless come off. The practicability of making a good steel-headed rail, by this method, is certainly proved.

Another kind of steel-headed rail is being produced by Mr. Coxe, at the Reading Railway Company's mill. The cut, Fig. 1, shows the method of laying up the pile (9 in.), the shaded parts being separate small bars of low cast steel, made at the William Butcher Steel Works, Philadelphia. Fig. 2 (full size) shows the steel as it appears in the finished head.

Fig. 1.

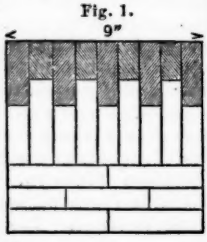
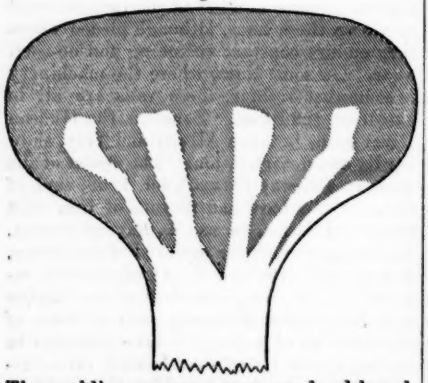


Fig. 2.



The welding appears very good, although the head cannot be as homogeneous as a solid slab. With some of the piles, borax, fire-clay, and sand were used as flux; with others, the Hindermeyer flux, which was quite satisfactory. Some 20 tons of these rails have been laid in one of the hardest places in the Reading track, which will soon determine their value.

THE HISTORY OF GUN-COTTON.

THE EARLY MANUFACTURE—ITS DANGER AND ABANDONMENT—LENK'S IMPROVEMENTS—NEW DIFFICULTIES—THE MANUFACTURE IN ENGLAND—ABEL'S IMPROVEMENTS—PRESENT PROCESS AND RESULTS.

Compiled from the London "Times."

In the year 1846 Professor Schönbein, of Basle, announced that he had discovered a substance possessing all the useful qualities of gunpower without the defects. Gunpowder is dirty, rather dangerous to manufacture, and leaves behind it when exploded both a considerable quantity of solid matter, fouling the piece within which it has been consumed, and volumes of stifling smoke. The invention made its way into popularity with great rapidity, for what can be more desirable than an explosive material of great strength in the form of a soft, clean substance that gives no smoke in its combustion, and leaves no traces behind? The idea of gun-cotton was not entirely new. Braconnet in 1833, and Pelouze in 1838, had produced a material called xyloidine, very similar in its nature to gun-cotton. Pelouze had even proposed its employment for artillery purposes, but the subject had never attracted much attention till Schönbein exhibited the substance itself to the British Association at Southampton in 1846 In the same year he proposed it for trial in France, Prussia and Austria. A general enthusiasm arose; and, while Messrs. Hall, of Faversham, began to manufacture it in England, foreign governments seized upon the idea, and began to carry it vigorously forward.

But if its popularity arose and spread rapidly, so did the reaction against it. Terrible explosions occurred in factories and magazines—not in one country, but in all. In England three men who were making gun-cotton rockets were killed on the 24th of June, 1847; and on the 14th of July such a fearful explosion happened at Messrs. Hall's factory that gun-cotton became as much dreaded as it had been welcomed before. The two buildings in which the manufacture was in progress had walls eighteen feet thick, and were separated by a huge mound of earth forty feet high. Yet the echoes of the first frightful roar had not been given back before the second building blew up. Late discoveries seem to throw some light upon this phenomenon, which has often

been noted as occurring even in gunpowder explosions. A distance of two or three hundred yards has been found insufficient to break this terrible sympathy—for sympathy it probably is. At Messrs. Hall's works twenty-one persons were instantly killed, and sixteen suffering wretches lay mangled or burnt upon the ground. The manufacturers would have no more to do with so deadly a material. No one could tell how either of the explosions had occurred. A dread mystery hung over the event, and Messrs. Hall set men to dig a deep pit, into which they threw all the gun-cotton they had made, right thankful to see it interred alive. And alive it was still. Sixteen years afterwards some of it was dug up for experiment. The rains had filtered through it. The earth, greatest of all chemists, had worked what it could upon the soft white mass, but its nature remained the same, and its force was but little abated. It is not necessary to say that gunpowder would, under such conditions, have melted into a black paste, and, gradually parting with its saltpeter, have become perfectly innocuous. The French government and the German Confederation were almost equally unfortunate ; and the worst feature was that no amount of care seemed sufficient to preserve gun-cotton from ignition. The ugly phrase "spontaneous combustion" was whispered about, and every report was unfavorable to the new explosive.

Among the officers composing the committee assembled from the different armies of the German Federation was a certain Austrian captain of artillery, called the Baron von Lenk. Agreeing with his coadjutors that gun-cotton, in its actual state, was not suitable for military purposes, he yet believed that it could be made so. Encouraged by Count Degenfeld, he prosecuted his experiments, and found out how to render it safer. He also tried to control its action; for one of the great faults of the old gun-cotton was its excessive rapidity of inflammation, and consequently destructive effect upon the gun in which it was fired. The safety was gained by a more complete conversion of the original material into gun-cotton, and its subsequent purification from all traces of uncombined acid, as far as was possible, in his method of manufacture. The regulation of the action was obtained, so far as it was obtained at all, by using skeins of twisted cotton in the first instance, and then winding them round wood, twisting them into ropes, or compressing them into comparatively solid masses. Some success was attained, and the Austrian government again took up the question. When an army of observation was placed in Galicia during the Crimean war, four batteries of eight guns each were provided with gun-cotton charges. There was no opportunity of trying them in battle; but experiments showed that the new material was uncertain in its action and destructive to the guns. Some of the charges even ignited during the process of loading. Artillery officers almost unanimously rejected gun-cotton; and it would have been forgotten, but that none of its objectionable properties seemed to hinder its employment for mining purposes, while the suddenness of its effects rendered it peculiarly well adapted for blasting rocks and submarine explosions. So the engineers received it as it fell from the hands of the artillery, and have never since entirely rejected it. They had stores of it in Venice and the Quadrilateral during the war of 1859; and even the artillery, being in want of something that could be called new to oppose to the French rifled guns, prepared gun-cotton batteries in Vienna, which were, characteristically, just ready for service when peace was concluded at Villafranca. Scarcely had a few rifled guns been made on the French system, when it was found that they would not do. Count Degenfeld was appointed Minister of War, and again brought gun-cotton forward for artillery. An ingenious system of rifling was devised, and tried with gun-cotton. The results were good enough to warrant the Minister in ordering thirty batteries (240 guns) to be prepared and equipped in the same manner. Some of the European nations which had dropped the subject since 1847, England being one of them, sent officers to study the details, and learn Lenk's system of making gun-cotton. But just then came reports of unlooked-for burstings of shells and mining charges in Italy or at Vienna, and, finally, the blowing up of a magazine at Simmering, near Vienna, where gunpowder and gun-cotton were stored together. The old mystery hung over the occurrence. No fire had been near the place, as well as could be learnt. It was enough. The Austrian artillery had burnt their fingers too often; they would have no more of this soft, white, treacherous substance, which promised so fairly only to betray. It fell completely out of favor, and nothing has been done with it since in Austria, except for mining purposes and torpedoes.

But the British Association had taken up the matter again in 1862, under the advice of General Sabine, R. A., President of the Royal Society. A committee was appointed, their report was read in 1863, and at last the English government appointed a committee to investigate the whole subject. According to British usage, they began at the beginning, and worked doggedly on through all previous experiments, leaving nothing unproved. They had just cleared the subject from most of the fog that obscured it, and the light was beginning to shine pretty clearly, when, again according to British usage, the committee was suddenly dissolved. Fortunately, Mr. Abel, F. R. S., chemist to the War Department, had become a convert to the possibility of eventually finding a substitute for gunpowder, either in gun-cotton or some analogous substance. His researches have already carried the subject far beyond any point previously attained, and the progress made has been so considerable that gun-cotton may now be considered as quite fit for sporting purposes, and on the way to become so for rifled small arms, perhaps even for field artillery. It appeared as if chemists could in nowise satisfy themselves as to the value of the material until they had put a hard name to it. As long as it was only gun-cotton it made no progress. It languished even as pyroxylin, but has moved steadily forward ever since it became tri-nitro-cellulose, a rich name and comfortable to the mind.

It was, therefore, not to see gun-cotton made and tried, but to witness the manufacture and investigate the properties of tri-nitro-cellulose that a party of scientific gentlemen and military officers, French and English, recently went down to Stowmarket. Mr. Abel's improvements have been adopted by Messrs. Prentice, and at their works alone can now be studied the latest forms which this material has put on.* The Austrian manufacture stopped at the point where the cotton was supplied in the form of skeins, which were dipped in a mixture of nitric and sulphuric acid, then placed in jars to soak thoroughly, then half dried in a centrifugal apparatus, and afterwards washed thoroughly and long by hand and in running streams until no free acid could be detected. For small arms cartridges a hollow plaited rope was then made of it, cut into lengths, and arranged round little wooden spindles, the ends of which penetrated the bases of their bullets and held fast there. When first Messrs. Prentice commenced their manufacture they were under the advice of Baron von Lenk, and followed the Austrian method exactly. Soon they found the rope plait was inconveniently long. They tried a solid pope, but it inflamed too suddenly and strained the gun. Then they tried a solid rope of mixed gun-cotton and common cotton. This was not so dangerous, but its action was not always the same. They tried also what may be called gun blotting-paper, and rolled it up into cylinders for cartridges, but they have now exclusively adopted Mr. Abel's newer methods, which have the two advantages of rendering the gun-cotton perfectly safe and almost perfectly manageable—safe because the great thing to be avoided is a mass of cotton, either imperfectly converted or containing free acid. Cotton, like hair in its ordinary state, is made up of a vast number of small tubes, which all have the power of taking in liquid by capillary attraction, and retaining it in spite of all washing. If there is any free acid in the gun-cotton it has many opportunities for combining chemically with other substances, and so setting up heat which accumulates, and may at last fire a portion of the mass. Mr. Abel obviates this by tearing the cotton into fragments, making it, in fact, into pulp. The process of making gun-cotton at Stowmarket is thus carried on :—

Rough waste cotton, no matter how short the fiber, is cleaned thoroughly, dried, and dipped into a mixture of three parts sulphuric acid to one of nitric. If the acids were weak, the cotton would dissolve. With the strong acids used a combination of the nitric acid and cotton ensues, while the sulphuric acid takes up the water left behind by the nitric acid and so keeps the latter always strong. There is a row of small tanks fed with acids through pipes from a reservoir. Into each of the tanks one pound of cotton is dipped, care being taken to immerse it all completely. It is then taken out and laid upon a grating over the tank to drain, and thoroughly squeezed by iron paddles. Twenty minutes suffice for this operation. The converted cotton now goes into jars, which stand in water to keep them cool, for much heat is

* The Messrs. Prentice commenced the manufacture of gun-cotton under Baron von Lenk's patents in 1863. We had an opportunity to witness the first experiments made by them, which, together with many other experiments and facts of interest concerning gun-cotton, are very fully considered in the appendix to "Ordnance and Armor."—*Ed. V. N's. Magazine.*

developed in the combination. After soaking here for many hours, the cotton is placed in a revolving drum with small holes in its exterior. It whirls rapidly round, and discharges most of the spare acid by its centrifugal force. Then comes a very important process—the washing. First the cotton is thrown into a fall of water, and a man watches to prevent any of it escaping instantaneous immersion, otherwise the acid and the water would set up an action strong enough to burn some of the cotton, or, at least damage it. After thorough washing in a tank under the waterfall the material is placed in a vat to steep in water for twenty-four hours; then it goes to a second and a third, and so on for a week. By this time no acid is perceptible. The cotton is then placed in a mill like that used in paper-making. The water used to make the pulp is slightly alkaline, in order to take up the last traces of acid. The next operation is drying again in a centrifugal machine. There has now been produced a gun-cotton pulp, which has only to be pressed into the shapes most convenient for its intended purpose. The most common forms are those intended for fowling-pieces and blasting. Another invention has lately been introduced to render the cartridges impervious to damp. There are 30 grains of cotton to a gun of No. 12 bore. One grain of india-rubber dissolved in 30 grains of spirit is then used to saturate the pressed gun-cotton. After drying, the spirit evaporates, and the caouchouc remains throughout the mass, completely preserving every particle from damp, though gun-cotton does not deteriorate by damp so long as it be dried again before firing. Almost everything that is made of gun-cotton has a hole through it to facilitate combustion. The pulp is first pressed in a very wet state, and then pressed yet smaller before drying. It is finally dried, and put in boxes for use. The pulp and various shapes into which it is pressed are Mr. Abel's inventions.

Such is the manufacture of gun-cotton. Some of its properties are most curious, and really deserve to be called sympathetic. For instance—take a loosely-twisted thread of gun-cotton, and lay it on a flat table, carefully drawing out a few filaments at one end, so as to form a point. Light a small piece of wood, a match if you will, but blow it out as soon as the wood is well inflamed. Approach the spark that remains delicately to the extended filaments. They meet it and begin to burn. But how? Very far from explosively. The whole thread smoulders away like touch-paper so long as no wind blows upon it. But blow the flame the least towards the rest of the thread, or even bring a flat surface close to it so as to push the heated gas for one moment back upon the thread, and the whole goes off in one flash in the ordinary way. Light it with the flame of a match, the whole flashes off at once. Go one step farther, and ignite it by a little detonating arrangement, the gun-cotton sympathizes again and actually detonates. Since this curious property was discovered, it has been found to apply to gunpowder in a more limited form; and here have we not the long-sought clue to the sympathetic explosion of one magazine after another even when at considerable distances apart? Neither a layer of air, nor water, nor even plaster of Paris, will save gun-cotton from detonating if there be an explosion of the same character near it. Here is a strange physical property which will be of the utmost value in mining. It is the sudden and violent effect of nitro-glycerine without its character of treachery to its friends. The miner has in his charge of gun-cotton two perfectly different physical forces stored up. He can call either of them into life at his will. Let him light his piece of prepared rope with any ordinary flame, even the explosion of gunpowder—the gun-cotton will give just such a rending strain as gunpowder gives—rather more rapid, but of the same nature. Place a small detonating tube inside your rope or leaning against it, ignite this, and the gun-cotton will explode with the same rapid, active, intensely local explosion, shattering to atoms all that is within reach. The smouldering form of burning is as yet too delicate to be made practical use of. The mildly explosive form is adapted for guns, the rapid shattering for any purpose where great local effect is to be produced, such as shattering rocks into small pieces, charges for shells, blowing down palisades, and generally breaking anything into pieces.

Illustrations of the two latter forms of explosion were given abundantly recently (Jan. 22). After seeing the processes of manufacture, the visitors went to the shooting-ground and not only saw some practice, but ascertained personally the comparative effect of gunpowder and gun-cotton in a fowling-piece with small shot. The penetrative effect was about equal. The gun-cotton cartridges threw closer, and in a very mark-

ed degree. It mattered not who took the gun in hand, the average difference was always about the same. The recoil of the gun was much less with gun-cotton than with powder. This is very well known, but we are disposed to venture a different reason for it from the one commonly given. It is usually said that the gas produced has to move solid grains of powder as well as shot. The difference must be very trifling, and cannot possibly account for the extraordinary want of kick in guns fired with gun-cotton cartridges. We believe that the action of the gun-cotton is more local because more rapid, and expands itself in creating motion in the particles near at hand when the explosion occurs, rather than in moving the whole mass of the gun. This theory seems to be confirmed by the fact that as gun-cotton is more diluted by inexplosive cotton it gives more recoil. If we are correct in this supposition, it is clear that the gun-cotton strains the gun more, but fowling-pieces have generally a large margin of strength, and the charge of shot moves much more readily than a bullet in a rifle. This supposition may also account for the closer throwing of shot from the gun, for the greatest pressure of the gas occurs while the shot is yet far from the muzzle; hence less tendency to separate at the momont of leaving the gun.

As the first experiment against palisades, a disc of gun-cotton, weighing about 1 lb. 1 oz., was placed on the stump of a tree lately cut down and ignited by an ordinary piece of miners' fuse. At the instant of ignition it was enveloped in flame and sailed merrily about for the two or three seconds required for its combustion. The gas produced lifted it up and caused it to move. Then about half the quantity was placed on the same spot and ignited by a small detonating tube. A sharpe, sudden report was heard, and the stump was found on inspection to be partly penetrated just where the charge had lain, while the twigs of the hedge close by suffered severely. On seeking for a new illustration, a large tree-root was seen which had been torn out of the ground, and offered among its gnarled and bossy structure a favorable position to deposit a charge. One of the discs about 1 lb. 1 oz. was accordingly placed at the mouth of a small cave that seemed inviting. The gun-cotton was not buried in the mass, but only laid as it were on a shelf perfectly open to the air. The gentlemen present retired to what they considered a safe distance, about 50 yards. There seemed to be some doubt about the effect. Is it possible that so small a quantity of gun-cotton could rend such a mass even if buried in it? Surely not when it is only laid on the floor of an opening. The moment of explosion is anxiously awaited. A man lights the fuse and runs for his life. There is a little smoke. Is the cotton burning as the first sample did? Wait a little yet. The tube has not given its sharp cracking sound. One moment more, and then a report and a rush through the air of masses of wood. Overhead, right, left, in front. everywhere. Soldiers who have known what it is to be under shell fire ducked to dodge a big lump of knotted wood that sprang 64 yards from its parent root, just clearing the heads of the party. It was only for a moment, and then everybody ran to see what had been done. The whole great root had simply been shattered to pieces. The next experiment was on a row of palisades composed of three trunks, some of them eighteen inches in diameter, and all sunk four feet into the ground. A long tree-trunk lay touching the foot of the palisade, and upon this 5 lbs. of gun-cotton was laid. Wires communicating with a magnetic apparatus were affixed to a detonating tube, which was placed in contact with one of the discs of gun-cotton. The time of suspense was short, and then the explosion was heard. One mass of wood only was seen to plunge away from the palisade; it was the recumbent trunk upon which the cotton had been laid. The palisades themselves were standing, though a good deal damaged. No practicable breach.

But there still remained a long space of palisading yet untouched, and here, instead of 5 lbs., 15 lbs. were laid, partly built upon each other. The excitement began to increase. It was the old story of the targets and the guns, and now several people might have been found to back the palisades. Fuse and wires were placed. Everybody retired to a safe distance. At last came the sharp, powerful crash, so unlike the dull roar of gunpowder, and this time there could be no mistake about the effect. Huge logs were seen performing somersaults at greater or less distances from the explosion, while smaller pieces, some about a couple of feet square, bounded like rabbits over the field. On reaching the target the effect appeared to have been tremendous. In some places a tree-trunk had been cut in half almost as if with a rough saw, only not so straight.

In others the solid wood was mangled so that it could be pulled to pieces by the hand. Three logs had been cut down or smashed, and it was clear that no stockade or New Zealand pah could withstand such deadly effects for an instant.

And all this had been done by only 15 lbs. of the cotton. Three times the quantity made up into a cylinder could be carried with ease by a man at a run, who might also drag the ends of the two wires as they unwound from a reel kept in a position of safety. No fire need be seen, for there is no match to light. Surely plenty of volunteers could be found to perform such work at night, and so restore the superiority of civilized man over savages! It had been contemplated to tie a ring of gun-cotton round a living tree, and see if it could not be cut down, but there was not time enough. The experiments were over for the day, and the visitors returned to London satisfied that they had seen a most marvellous phenomenon, and one which is only a first step to a whole array of novelties in the arts of war and of peace.

FRENCH NAVAL ENGINES.

Notes on the comparative experiments on three cylinder Engines in the Imperial Marine, by M. le Vice-Admiral Labrousse.

Translated for "Van Nostrand's Magazine" from "Le Génie Civil."

(EDITOR'S NOTICE).

The readers of "Annales du Génie Civil" will recall that one of the most important questions connected with the application of steam to war vessels, has been already discussed in our magazine. We refer to the determination of the relative merits of two systems, simultaneously employed in our navy. The one, derived from the Woolf system, (but which does not make use of very high pressures nor of great expansions,) introduces the steam directly into a central cylinder, during $\frac{85}{100}$ of the stroke, and then allows it to expand into two other cylinders attached to the first and of equal capacity. The other system, which employs steam at a moderate pressure, gives it access to each of the three cylinders through $\frac{30}{100}$ to $\frac{65}{100}$ of the stroke, according to circumstances.

Vice-Admiral Labrousse, as the result of prior experiments and the most exhaustive theoretical considerations, endeavored in the article alluded to, to show that this latter system has incontestable advantages over the former, both in a mechanical point of view, and in its military relation, and concluded by insisting upon the immediate abandonment of the objectionable system, and the transformation of its machinery—a matter of no great difficulty. The arguments of the honorable admiral, whose qualifications in all that relates to steam engineering nobody will venture to question, have not, it would seem, been regarded by the directing administration as sufficiently conclusive to warrant the instant adoption of so sweeping a decision; but it has seemed advisable to seek in new experiments a more decided and authoritative comparison and more accurate results upon so grave a question. During the past summer many instructive experiments were undertaken by the iron-clad division of the navy; the programme, it is but justice to say, having been arranged by M. Puys de Lôme, the author of these same engines which are charged with inferiority. In this case, as in all others, to the party on trial belongs the right of the last word in his defense, until the investigation is completed, and the judges are ready to render a decision. It certainly seems that the time for a decision has fully come, and any further postponement of the issue will look like favoritism, and can only, in the opinion of the admiral, aggravate a situation already most deplorable, nay even fatal, and upon which they cannot, in any other way, shed one ray of light. With a view to bringing home to learned and impartial men his own convictions in this matter, the honorable admiral submits to their judgment all the steps of his investigation, the results of which supremely affect the interests and honor of France, relating as they do to one of the capital elements of her military power. If we were to express merely our own opinion, we should say that our conviction, already prepared by the previous paper of M. Labrousse, is now complete; for it seems impossible to oppose a single valid argument to inferences so clear and convincing. But it is to the enlightened public, to whose judgment the admiral makes his solemn appeal, that the right belongs of deciding between the two opinions before it on this grave question—COMITÈ DE REDACTION.

The armored frigates *Savoie*, *Gauloise* and *Guyenne*, which form a part of the Oceanic naval division, were subjected, a while ago, to some comparative experiments, relative to power and consumption. The *Savoie* has an engine with three equal cylinders, with

direct admission into one of them; the *Gauloise* has also three equal cylinders, but with direct admission into all of them; the *Guyenne* is furnished with the ordinary two cylinder engine. The experiments, conducted according to a carefully elaborated programme, have been made with the utmost care. "Nothing whatever," says the report of the commission presided over by Rear-Admiral d' Hornoy, "has occurred to interrupt their course, or to affect, in the smallest degree, their validity." We may therefore consider the results as having all the correctness which is consistent with the official programme. In a former paper, containing an examination of the three cylinder engines, we had arrived at some summary conclusions, founded upon various theoretical considerations, which arose from an exhaustive discussion of the experiments before us. We put them in the following form:

If we compare the new engines of the *Savoie* type with the three independent cylinders of the *Gauloise* type, we must conclude from the foregoing discussion that the latter are superior in every respect.

1. They are on the same footing with respect to consumption of fuel, and yet the latter have attained, with a boiler pressure less than 59 centimetres [of mercury], a power in excess of 4,000 horses.

2. They offer better security for attaining a great number of revolutions, because their method of coupling is more regular [equiangular], because the maximum pressure upon the journals is 50 per cent less, and because injurious effects of heat are less to be apprehended.

3. The static equilibrium of those parts subjected to alternating motion, is more exact—a result of the more regular manner in which the cranks are attached to the shaft.

4. To attain a normal power of 4,000 horses, we can in the engines of the *Gauloise* type, reduce the working velocity adopted for those of the *Friedland* or *Savoie*, either by increasing the pressure (without reaching even 133 centimetres), or by increasing the admission; while in the *Friedland* or *Savoie* type, this power cannot be attained except by exceeding the normal pressure of 133 centimetres, and increasing the working velocity, which is already too high.

5. Finally, as the normal admission in an engine of the Gauloise type, is only $\frac{4}{10}$, when the boilers are deteriorated, we can, without diminishing the power, employ a larger admission, and thus work at a lower pressure, which is impossible with the new engines, in which the admission is already $\frac{85}{100}$.

The experiments with the armored vessels of the Oceanic division, have confirmed these various assertions in the most complete manner, and all the more conclusively because they were conducted upon a programme laid down by the very author of the *Savoie* type of engine. We shall set out these facts in a manner that ought not to leave any doubt in the mind of any reader, however prejudiced in favor of the latter system.

Meantime we may venture the remark, that our object is only to establish an abstract and general comparison between ordinary engines and established machinery after the Woolf system, (properly speaking,) with high pressures, which involve the use of surface condensers when sea-water is the only available source of supply. This will give rise to a question which we shall probably have occasion to touch upon further on, when we come to discuss the military requirements of a vessel. Our present task is less complex. In a word, it amounts to this:

The French fleet contains, either in service or building, nine three-cylinder engines of a thousand nominal horse-power; two with independent cylinders, and seven with direct admission into only one cylinder, according to a system derived from the Woolf principle. In all these engines the boilers are fed with sea-water. The pressure in the boilers should therefore be limited, in the seven engines of the second type, to 133 centimetres—a maximum, beyond which the author of these engines himself admits that deposits of salt cannot be avoided. What we urge is the transformation of these seven engines into engines with direct and independent admission into the three cylinders, for the sake of advantages of every kind, mechanical and military, which undeniably appertain to the latter class. The conversion can be effected with little difficulty, and without affecting materially the internal arrangements of the vessels, and we have already seen by the analysis and discussion of the experiments made with the armored division of the north, that delay in this matter is no longer tolerable. But we proceed to our demonstration.

1. *Experiments proving à fortiori, our first conclusion; greater power with less boiler pressure and equal consumption of fuel.*

TABLE I.

NAME.	Pressure, Centimetres.	Power, H. P.
Savoie	115.8	2,565
Gauloise	60.	3,157
Difference	55.8	592

These figures show at once in favor of the Gauloise an actual power one-fourth greater with about half the pressure.

The consumption of coal, in the determination of which no possible means were neglected which might ensure perfect exactness, are compared in the following:

TABLE II.

Relative consumption per hour and per horse-power of 75 kilogrammetres.

NAME OF VESSEL.	1 Boiler.		2 Boilers.		4 Boilers.		6 Boilers.		8 Boilers.	
	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.
	K.	°	K.	°	K.	°	K.	°	K.	°
Savoie	1.967	2.690	1.484	2.480	1.485	2.49	1.494	2.240	1.543	2.32
Gauloise	1.940	2.825	1.603	2.800	1.454	2.76	1.390	2.734	1.369	2.75
Difference	+0.027	.....	—0.119	.....	+0.031	....	+0.104	.....	+0.174	.....

TABLE III.

Consumption reduced to 3° of saturation.

NAME OF VESSEL.	1 Boiler.		2 Boilers.		4 Boilers.		6 Boilers.		8 Boilers.	
	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.	Consumption.	Saturation.
	K.	°	K.	°	K.	°	K.	°	K.	°
Savoie	1.929	3°	1.428	3°	1.433	3°	1.400	3°	1.460	3°
Gauloise	*1.920	3°	*1.579	3°	*1.432	3°	1.365	3°	1.331	3°
Difference	+0.009	....	—0.151	....	+0.001	....	+0.035	....	+0.129	....

The report of the commission gives, for the consumption reduced to three degrees of saturation, the figures in place of

1,876	1,605	1,463
1,920	1,579	1,432

which are given respectively in table III, and which are marked by an asterisk. It is apparent that some sensible errors have crept into the reductions made by the commission, and we have worked out the corrections, after having made sure, in comparing the total consumptions, the duration of the experiment, and the horse-power obtained, as set forth in the tables of the commission, that the figures 1,940, 1,603 and 1,454 are correct.

It appears from the foregoing tables that the advantage rests with the Gauloise in every case but one, and that with two boilers—that is, with one-fourth the fires lighted—an exceptional case, which we have never seen in actual service.

With respect to the power developed, it was during the trials of June 27th, 1868, greater by about 600 horse-power (or one-fourth greater) on the *Gauloise* than on the *Savoie;* while the pressure, which was 115.8 centimetres on the *Savoie*, did not exceed 60 centimetres on the *Gauloise*. The first of our conclusions is thus confirmed, even beyond our expectations; but even though the commission had reversed the results—that is to say, even though the *Savoie* was made to show in the report of consumptions an advantage which properly belonged to the *Gauloise*, we none the less continued to urge the conversion of engines of the *Savoie* type into the *Gauloise* type, taking our stand upon the following considerations, which we explained in our first paper upon these engines.

"An economy reaching even 20 per cent (M. Dupuys de Lôme's figures in his note to the Academy) is not sufficient to compensate for the defects of his engine. The defects are all the more serious because their principles may pass unobserved in time of peace; for the occasions on which the machinery of our war vessels will be called upon to develop their utmost power, will be rare and of brief duration; but in war, and in the hours of supreme emergency, the speed, which, in M. Dupuy de Lôme's engines requires the highest pressures and a perilous velocity of the piston, will be often demanded and will be had whatever the cost. Their dangerous character will then be fully realized."

We proceed to examine our second conclusion. The more perfect equality of the couple of rotation in the *Gauloise* engine, appears from the fact reported by the commission, that the *regular* motion may be reduced down to nine revolutions [per minute], while in the *Savoie* it ceases to be regular at twelve turns [per minute]. If the power may be regarded, within the limits compared, as proportional to the cubes of the number of turns, then the minimum forces consistent with the regular performances of the two will be in the ratio of 729 to 1,728, or as 1 to 237. The first part of our second conclusion then is abundantly warranted by the experiments of the Ocean division.

With respect to the second part of that conclusion, viz: maximum pressures upon the journals; it is well sustained by results. We have elsewhere demonstrated that, supposing the mean pressures to be equalized in the cylinders of the *Savoie*, the interposition of inertia would involve a great increase of relative pressures upon the journals. This increment of pressure will be greatly augmented in the present case, because the mean tensions of the steam are widely different in the different cylinders. Finally, we asserted that injuries resulting from the high temperature of the steam are less to be feared in the *Gauloise*. We infer this from the fact that about the same powers are obtained on the *Gauloise* (3,157 horses), with 60 cm. of boiler pressure, representing 117° C., and on the *Savoie* (3,215 horses) with 141.8 cm. of pressure, representing 134° C.

Our third conclusion as to the static equilibrium of moving parts was evidently correct *à priori*, so far as it applies to the *Friedland* type of engine, of which the cranks are attached at 90 and 135 degrees. On the *Savoie*, where the cranks are attached at 120 degrees, (the same as the *Gauloise*), the inferiority of the static equilibrium shown in the experiments, results from the difference in the tension of the steam in the cylinders, which the attachment at 90 and 135 degrees is expressly intended to obviate, but is more injurious than useful in the present case.

Our fourth conclusion is with reference to the means of obtaining great power with low pressures in the *Gauloise* type. This would be evident enough *à priori*. But to show that it is sustained experimentally, it may suffice to quote the figures. The *Gauloise* has developed 3,544 horse-power with $\frac{4}{5}$ admission and 88.8 cm. of pressure, while the *Savoie* has developed only 3,215 with 141.8 cm. Comment is superfluous.

There remains the fifth conclusion, viz: sustained power in spite of deterioration in the boilers. The Gauloise realized (17th of June) 3,157 horses with only 60 cm. pressure, while the Savoie, to realize an equal power (3,215 horses), had to push the pressure to 141.8 cm., and with 105 cm. her power reaches only 2,207 horses; indeed at this moment the boilers of the *Magranime*, (same engine) though in good condition as yet, are so weakened over the fires, that it is not deemed prudent to exceed 100 cm. of pressure, and the engine is barely capable of developing more than 2,200 horse-power; while if it had belonged to the Gauloise type it might, with this pressure, attain 4,000 horse-power, as has been experimentally shown in the Gauloise.

Altogether, the last experiments in the armored Ocean squadron have brought clearly and thoroughly to light all the de-

fects we had charged upon the engines recently introduced into the Imperial marine, and justified the conclusions we had formed. A single one of these conclusions, (that one *à fortiori* in favor of our opinion,) has not been found exactly in accordance with the facts. It is that relating to economy of fuel. In view of precedents, we had asserted that the consumption of fuel for the whole amount of steam generated would be about the same in both types. In actual experiment the *Gauloise* showed a marked advantage over the *Savoie*. In view of results so complete and convincing, we need not wonder that the superior commission expressed itself as follows at the announcement of its conclusions: "The facts speak for themselves. The comparisons of the three types of engines have, in the opinion of the superior commission, demonstrated the advantages of the three cylinders with direct admission of the steam, &c."

Since "the facts speak for themselves," we shall add nothing to our argument, and conclude by saying that the conversion of all the Savoie and Friedland engines into the other type, with three independent cylinders, should be no longer deferred.

VICE-ADMIRAL LABROUSSE.

A NARROW GAUGE RAILWAY.

THE BRÖELTHAL VALLEY LINE—TWO FT. SEVEN IN. GAUGE—PARTICULARS OF THE ROAD, ENGINES, CARS AND WORKING.

Compiled from "Engineering."

The railway connecting the valley of Bröl with that of Sieg, near Cologne, of which we propose to give some particulars, is of interest to engineers not only on account of the narrowness of its gauge, which is 2 ft. 7 in., but also on account of the success with which its working has been attended. The line leaves the Cologne and Giessen Railway, at Hannef, and with the exception of a short length near that station it is constructed along the line of the ordinary road, the administrative authorities having permitted a width of about 4 ft. 8 in. to be taken from the latter for the purposes of the railway.

The Bröelthal valley line was originally designed exclusively for the accommodation of the mineral traffic to the works of Friedrich-Wilhelm-hutte; but the inhabitants of the surrounding districts found it to be to their interest to employ the line for the conveyance of their goods, as the cost of transportation was found to be about 66 per cent cheaper than by the ordinary roads; and as a result the line has at the present time a considerable general goods traffic. The main portion is about 12½ miles in length, and with the exception of about ⅝ mile is constructed, as we have already stated, along the ordinary road. At a station called Schöneberg, a branch about 1½ miles in length extends to Sauerbach. The company are also on the point of extending the main line from Ruppichteroth to Waldbröl, a distance of 6¼ miles; and as this portion of the line cannot be constructed along the ordinary road, the Prussian Government have granted the company a subvention of 60,000 francs (£2,400), in return for which the company have engaged to establish a passenger service over their whole system. The stations on the main line are eight in number. Besides these there are watering stations for the supply of the locomotives. All the buildings are of the simplest kind, and the arrangements for supplying water to the locomotives consist simply of wooden cisterns filled by hand pumps.

The railway follows exactly the course of the road, and it includes curves of 38 meters (124 ft. 8 in.) radius, and inclines of 1 in 80. The line is always carried on the most dangerous side of the road, and it occupies a width of 4 ft. 8 in., the total width of the road being 24 ft. 9 in. Permission has also been given, in case of a new line being laid down, to increase the width occupied to 6 ft. The upper sides of the rails are on a level with the footpath, and at intervals channels are provided for the escape of the drainage water. Near Hennef, the line, together with the road, passes over the river Sieg on a wooden bridge, which was constructed at the expense of the company, but of which they keep in repair only that portion traversed by their line, paying for the maintenance of the remainder an insignificant annual sum.

At Hennef the Cologne and Giessen line is above the level of the surrounding soil, and a siding serves to conduct the larger wagons to hoppers, into which the minerals are discharged, and from which they are delivered into the wagons of the Bröelthal valley line. At the basement of the range of hoppers are the goods offices, and a running shed and turn-table for the locomotives, and a weighing machine.

The line is worked by two small tank locomotives, these engines running alternate weeks. These locomotives were constructed at Carlsruhe. They have six driving wheels in a rigid frame, and outside cylinders. The principle dimensions are as follows:

	ft.	in.
Diameter of cylinders	0	$10\frac{3}{16}$
Stroke	0	10
Diameter of wheels	2	$3\frac{1}{4}$
Distance between centers of leading and driving wheels	3	$8\frac{1}{4}$
Distance between centers of driving and trailing wheels	2	11
Total wheel base	6	$7\frac{1}{4}$
Diameter of barrel of boiler	2	$9\frac{7}{8}$
Number of tubes 73		
Length	5	7
Diameter	0	1.38
Length of firegrate	2	4
Width	1	$6\frac{1}{4}$

Heating surface.

Tubes	147	sq. ft.
Fire-box	27	"
Total	174	"
Area of fire-grate	$4\frac{1}{4}$	sq. ft.
Pressure of steam	90 lb. per	sq. in.
Weight of engine in working order	$12\frac{1}{4}$	tons.

The wagons employed on the line are almost all of the following dimensions, etc.:

	ft.	in.
Length of body	10	2
Width	4	8
(In the new stock this width will be increased to 5 ft. 4 in.)		
Mean depth of body about	5	3
Diameter of the wheels. 2 ft. $6\frac{3}{4}$ in. to	3	1
Wheel base. 4 ft. 6 in. to	5	2
Diameter of axles. 3 in. to	0	$3\frac{1}{4}$
Weight empty $2\frac{1}{4}$ tons.		
Load carried 5 "		
Total weight loaded $7\frac{1}{4}$ "		
Weight per wheel $1\frac{1}{3}$ "		
Cost per wagon £56 to £92.		

The bottoms of the wagons incline from the center downwards towards each side, so as to discharge the minerals through side doors. The longitudinal frames of the wagons are of iron of channel section; and the springs are arranged, as usual, above the axle boxes, the latter being protected by flaps of leather or canvass, as on ballast wagons, to prevent the dust from the minerals, when the latter are discharged, getting to the bearings. The wagons have central buffers placed above the draw hooks, each buffer rod being connected with the corresponding draw bar by a lever, so that the draw spring serves also as a buffer spring. The draw springs are of india-rubber. Some of the wagons have cast iron disc wheels without tyres, whilst others have wheels of the ordinary kind with tyres of puddled steel. At first the wagons were run with one wheel of each pair loose on the axle; but the results were not found to be satisfactory, and the plan was therefore abandoned.

The line is laid with rails of the following dimensions: Depth of rails, $3\frac{1}{8}$ in.; width of the top table, $1\frac{5}{16}$ in.; width of base, $2\frac{5}{8}$ in.; thickness of the web, $\frac{7}{16}$ in.; weight, from 22 lb. to 26 lb. per yard. The rails vary in length from 14 ft. 9 in. to 21 ft. 8 in., and they are carried upon transverse sleepers of oak, 4 ft. 2 in. long, 6 in. wide, and $5\frac{1}{2}$ in. deep, placed at a distance apart of 2 ft. from center to center. In the case of the sleepers at the joints, the width is increased to 8 in. The rails are secured to the sleepers by spikes, and they are connected by fish-plates $12\frac{1}{4}$ in. long, held by four bolts $\frac{1}{2}$ in. in diameter. The gauge of the line is, as we have already stated, 2 ft. 7 in., but on curves of 40 meters (131 ft. 3 in.) radius the gauge is increased to 2 ft. $7\frac{1}{2}$ in. The super-elevation of the exterior rail on these curves is from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. A trial was made on the curves of small radius of ordinary flat-footed rails, weighing 72 lb. per yard, laid without cross sleepers, but the experiment was not successful. Formerly also movable rails were used instead of the regular points; but now ordinary switches are employed. The crossings are made of hard cast iron. The extension of the line from Ruppichteroth is to be laid with rails weighing 34 lb. per yard, but the distance between the sleepers is to be increased, and they are to be placed at a pitch of 2 ft. $11\frac{1}{2}$ in. from center to center. The rails laid on the main line, between Hennef and Ruppichteroth, cost £8 18s. per ton, and the fish plates £12 12s. per ton. About 15 tons of rails and 1,000 sleepers are used annually in keeping up the line.

We must now say something concerning the manner in which the line is worked, and its commercial results. The usual load drawn by the engines consists of 28 wagons loaded with five tons each, giving 140 tons of paying load. The total weight of the train is thus, as follows:

	Tons.
Locomotive	$12\frac{1}{4}$
Wagons.	70
Load in wagons	140
	$222\frac{1}{4}$

It is found that the engines can easily draw 36 loaded wagons, but the above is the usual load. The speed on the level portions of the line is a little over nine miles per hour; and in traversing those portions of the road at which there are habitations, this speed is decreased to about 5½ miles per hour. In case of meeting a vehicle with horses not accustomed to the passage of the train, it is the rule to stop, and by means of the brakes, which are in charge of five men, the train can be brought to a stand in a distance of about 130 ft.

But one train is run over the line each way per day. This train leaves Hennef at 6 A. M., and arrives at Ruppichteroth at 8. 30 A. M., departing from the latter place at 1 P. M., and arriving again at Hennef at 4 P. M. The line is worked with but a small staff. The managing director is M. Gustorff, who resides at Cologne, and who is also the managing director of Friedrich-Wilhelmhutte, while the line is in the special charge of M. Saling, who bears the title of inspector, and whose head-quarters are at Heunef, where a book-keeper is also employed. Another sub-inspector is stationed at Schöneberg, and three men are employed in keeping up the line, one of them receiving 1.875 francs (about 18d.), and the two others 1.8 francs (rather less than 15d.) per day. The men in charge of the train, and their wages, are as follows:

	s.	d.	
1 Engine driver	3	1¼	per day.
1 Fireman	1	8	"
1 Guard	2	1	"
4 Brakesmen, each.	1	7	"

There are no signalmen employed on the line.

The merchandise transported is divided into four classes, which are carried at different charges, the goods comprised in the first class being those least liable to injury. The tariffs are as follows:

Class.	Charge per ton for the entire distance. s.	d.
1st. Minerals, limestone, etc	7	0
2d. Burnt lime, iron, bricks, etc	8	0
3d. Grain and fruits	9	5
4th. Miscellaneous. (The tariff for this class varies according to the weight.)		

The goods belonging to the three first classes are, in addition to the above tariffs, subject to a fixed charge of 4d. per ton for loading and unloading. During the year 1864 (the latest year of which we have detailed particulars) the total quantity of goods carried over the line amounted to 32,709 tons, this quantity being divided as follows:

Class.	From Ruppichteroth towards Hennef.	From Hennef towards Ruppichteroth.	Total tonnage for each class.
	Tons.	Tons.	Tons.
1st.	27,970	2,860	30,835
2d.	344	840	1,184
3d.	140	335	475
4th	50	165	215
	28,509	4,200	32,709

The total receipts for the transport of the above quantities of goods was £2,800, showing an average charge of a little over 1s. 8d. per ton; while the working expenses during the year were £1,452, of which £120 was fairly chargeable to the succeeding year. The difference between receipts and expenditure, available for interest on original cost, etc., was thus, £2,800—£1,332=£1,468. The working expenses were divided as follows:

	£
Charges for management	150
Traffic charges	188
Cost of traction	428
Station charges	177
Maintenance of way	234
Maintenance of rolling stock	216
Miscellaneous	59
	£1,452

During the year 1867 the receipts amounted to £2,584, and the expenses to £1,301, leaving a balance of £1,283 available for dividend, etc. The total cost of the line and rolling stock, etc., has been as follows:

	£
1. Permanent way of main line	9,114
2. Bridge over the river Sieg with accessory works	3,593
3. Branch line to Sanerbach	1,575
4. Stations and depots	3,363
5. Locomotives and rolling stock	4,165
6. General stores	505
	£22,317

The total cost was thus about £1,526 per mile for the total length of the line. The sum given under the fifth head is divided as follows:

	£
2 Locomotives with spare wheels	1,753
29 Wagons without wheels and axles	1,405
101 Axles with wheels	887
Accessories	28
Tools, etc	92
	£4,165

The estimated cost of the extension of the line, a distance of 6¼ miles, to Waldbröl, is £9,490.

THE SOCIETY OF ENGINEERS AND ASSOCIATES.

Without discussing, at this time, the objects and duties of institutions of engineers, we merely wish to call attention to the fact that this New York Society is in some respects differently organized from many others, and that it has in some respects done the best work of any of our societies. The movement which created the present Society of Engineers and Associates, had its origin rather in a feeling of what ought to be done in this direction, than in a conviction that the time had come when such things could be done. Its present success, however, proves that it has one essential and, among us, almost new element of life in it, viz: that its meetings are attractive. Of course the purest science and the dryest formality are the correct theoretical features of engineering meetings, but the first society in the world—the Institution of Civil Engineers in London—does not dispense with those appeals to taste, both æsthetical and physical, that are found necessary to bring men together for almost all purposes except daily and routine business. In a new country, especially when the results growing out of association for scientific purposes are not direct and immediate, the right men are few and scattered, and if not full of engagements in the evening, as well as in the day, they are glad enough to devote the few unoccupied hours to recreation. Now, a stiff meeting, in an upper room, with a bad light and worse air, is not likely to attract the overworked engineer. He may attend from a sense of duty, but as a rule the engineers' meetings of a city, thus meagerly provided with a professional home, will consist of the gathering together of two or three in the comfortable study of a fourth. But while such gatherings lack the grand element of numbers, in which there is strength, they possess the equally essential element of attractiveness. Now, by combining the two, men will come in numbers, and getting the men at stated times is three-quarters of the battle. When they see their peers about them, they will not be long in organizing ways and means to get at the information there is in them. Proceeding upon this principle, the Society of Engineers and Associates have held their monthly meetings in a parlor at Delmonico's. While the proceedings are purposely informal, rather than rigidly parliamentary, they are not aimless nor desultory. The membership is made up of the principal engine, machinery and shipbuilders of the city, and there is, therefore, no lack of subjects upon which information is wanted and can be given. Nor are professional subjects alone considered. A great object is to promote good feeling among the members, and harmonious action in the business and enterprises they represent. An attractive meeting place, and an agreeable supper after meeting, are wise features of the plan. Anglo-Saxons, especially in England, find it necessary to dine together in order to accomplish any enterprise in which several interests are associated. But the parliamentary features are not wanting. There are standing committees, having chairmen and secretaries, to look after the various interests represented, and to prepare business for the general action of the Society.. Thus the meetings, to which it is specially desirable to attract the talent and learning that would otherwise stay at home, are relieved from the formality of preparatory business, and the discussion of special, local, and, to the professional public, uninteresting details. At a mere nominal fee of $10 per year. proper persons not residing in New York are admitted to the Society. The annual meetings (the last Thursdays in January) are of a more general and entirely social character. The last annual meeting, at Delmonico's, called out a greater number of professional men, especially in mechanical engineering, than we remember to have ever seen collected before in this country. It included prominent builders from neighboring cities, and prominent officers of the Army and Navy, and distinguished scholars from our scientific schools. Altogether it was more like a conversazione of the Institution of Civil Engineers, in London, than any gathering that has heretofore taken place on this side of the Atlantic. In this way, in addition to its more local and business labors, the Society of Engineers and Associates is doing great good, by attracting together the right men, promoting acquaintance and good feeling, and thus *actually showing* people more in a few hours, of the usefulness and possibility of a more perfect and comprehensive organization, than could be taught them by years of individual theorizing.

LOCOMOTIVES FOR HEAVY GRADES.

A NEW SYSTEM.

Translated and condensed from Polyt. Centralblatt.

We find in the history of the locomotive not only an astonishing development of constructions, based on the principles of Trevithik and Stephenson, but also a great number of systems which, like those of Murray and Blenkinsop, affect the locomotion of the engine by means of a rail with spur-gearing lying in the middle of the track (mid-rail), or in some other similar manner, thus to enable the locomotive to ascend heavier grades. Baldwin, of Philadelphia, built in 1848, two engines according to this plan, for the Madison and Indianopolis railroad, and afterwards some engines with horizontal driving-wheels for smooth mid-rails were constructed by Sellers, for the Panama railroad. Recently, Fell made the bold attempt to construct a temporary railroad with very heavy grades and sharp curves over the Mont Cenis, in using a similar system. However, as the success of Fell's arrangements has become more and more doubtful of late, the heavy grade problem is attracting once more the attention of engineers. With a view of solving this problem, K. Wetli has published a pamphlet containing an elaborate expose of a new system, a general idea of which we intend to give our readers in the following lines:

Wetli's system has a distant resemblance to one of the older schemes of railway and locomotive construction for heavy grades. According to this older scheme, a short, strong screw, attached to the engine below its frame, and situated parallel to the track, is turned by steam-power and works itself along a concave mid-rail with oblique indentations, thus pulling the engine forward. Wetli's locomotive is also provided with a kind of a screw or rather a double worm-wheel, which, however, is placed at a right-angles to the track, its axis being about eighteen inches above the level of the rails. It consists of two strong screws, one right, the other left-handed, both fixed to the same axle, touching each other in the middle of this axle, and extending almost over the whole width of the track. This worm-wheel receives its motion by a connection with the driving-wheels of the engine. Its object is to help the engine along on steep gradients. For this purpose straight guide-rails are laid between the ordinary track-rails in a transverse position, corresponding to the thread of the worm-wheel. They are laid in couples, the two rails of each couple touching each other at an angle in the middle of the track, and reaching on the other hand the vicinity of the interior faces of the track-rails. They are nearly five feet apart. As these couples of transverse rails are strengthened by cross-beams inside the angle, the whole track has about the appearance of two parallel lines between which a succession of letters A are inscribed one above the other.

The described mechanism is not, however, intended to give motion to the engine exclusively, nor to act under ordinary circumstances. When on moderate gradients, and in favorable weather, the friction of the ordinary driving-wheels is sufficient to overcome the existing weight of the train, the engine moves on in the usual way and the worm-wheel does not touch, or scarcely touches the guide-rails. But as soon as, under less favorable circumstances, this friction becomes insufficient, a sliding of the driving wheels takes place, by which the thread of the worm-wheel is brought in contact with the transverse guide-rails, and from this moment the driving-wheels and the worm-wheel begin to work conjointly. These are the general principles of this new system, according to the account given in Wetli's pamphlet. The inventor and author further relates in an ingenious and apparently successful manner, the principal objections that might be made to his system, and finally claims for the latter the following advantages:

1. The wagons of ordinary railways can pass unaltered on the track of the new system.

2. The locomotives of the new system can pass unaltered on ordinary tracks.

3. The working capacity of the locomotive is fully utilized, because its power of traction can be and is considerably increased at the expense of its velocity at any such time and to such an extent as the circumstances require.

4. The rate at which the current working expenses rise with the greater steepness of the road, is considerably less in the new system than in the one actually in use on the Mont Cenis railroad.

5. The running of the trains is not dependent on the weather or other exterior circumstances, and all irregularities in the service of the road that might otherwise result from this cause, are thus avoided.

S.

EFFECTS OF PHOSPHORUS IN IRON AND STEEL.

From a paper read before the Chemical Society "On the Connection between the Mechanical qualities of Malleable Iron and Steel, and the amount of Phosphorus they contain," by Dr. B. H. Paul, and the ensuing discussion.—"Chemical News."

It is generally considered that very small quantities of phosphorus in malleable iron and steel are most prejudicial to the quality of the metal. Quite recently, an eminent metallurgist has stated as a fact that much less than .3 per cent of phosphorus produces a decided and injurious effect on steel. The author has, however, been unable to discover any evidence sufficient to justify such a conclusion, and still less any reasonable explanation of it. He has recently had an opportunity of testing the truth of this conclusion, by determining the phosphorus in some samples of the iron and steel made by the new nitrate of soda process from British pig-iron known to contain phosphorus. Seven bars of iron and two bars of steel, made by the Heaton process, were examined; their tensile strength and extension had been determined by Mr. Kirkaldy. The iron bars had a tensile strength of from 46,547 to 52,824 lbs. per square inch of area, and an extension, when subjected to this strain, of from 21 to 28.6 per cent of their length. The two cast-steel bars had tensile strengths of 80,916 and 106,602 lbs., and extended 3.3 and 13.7 per cent of their lengths. In the iron bars, the author found .144 to .38 per cent of phosphorus (average .237 per cent), and in the two steel bars .24 and .241 per cent. The author, therefore, thinks himself justified in asserting that the commonly received opinion on this subject does not always represent the truth.

Professor Miller has had opportunities of examining some of these steels. It fact, he might say that Dr. Paul's experiments had been suggested by himself. He had found in some careful analyses of his own, very unusual quantities of phosphorus, even in samples of high class iron—iron which worked well cold, and also at a red and bright yellow heat. It could hardly be doubted that in many statements of the composition of iron the amount of phosphorus found had been too low. The old method of estimating the phosphoric acid, which involved the throwing it down as iron-salt, was unreliable. The phospho-molybdate process, employed by Eggertz, was undoubtedly the best; but even this required the greatest care to avoid getting too low a proportion of phosphoric acid. It was very difficult to ensure the entire precipitation of the phospho-molybdate. One thing was clear from these experiments, namely, that the presence of from two to three parts of phosphorus in 1,000 of iron was not so detrimental as was generally supposed.

The President inquired how the phosphorus existed in the iron, and the form in which it was eliminated during Heaton's process.

Professor Miller could not speak with certainty of the condition of phosphorus in the iron; it probably existed as phosphide. It was, however, most certainly eliminated in the form of phosphate.

Dr. Price remarked that there was nothing new in the statement that such quantities of phosphorus might exist in wrought iron, but that with regard to steel he had yet to learn that .24 per cent of phosphorus could be present without injuring the metal. With regard to methods, he believed that the one at present in use was absolutely correct, that, namely, in which the phosphorus was separated as phosphate of iron, and then determined with magnesia. The molybdate method was excessively tedious.

Mr. Forbes said that in Sweden they would not receive for making steel, iron that contained .1 per cent of phosphorus. Many works had had to stop for want of ores that were free from phosphorus. For one mine of such ore there were ten which yielded ore containing phosphorus, and they would most gladly use it if they could. He could not agree with Dr. Miller that the amount of phosphorus in iron was under-estimated. The molybdate process was thoroughly understood in Sweden, and had been in use since 1856. Errors in the estimation of phosphorus could not be due to ignorance of that method.

Professor Miller explained that he only meant to say that the molybdate process required care. No doubt the results obtained by Eggertz were perfectly correct. In answer to the President, Professor Miller then gave a short account of the Heaton process. A quantity of the niter was placed in a wrought-iron pot lined with fire-clay; on this was put a perforated plate of iron, and 12 cwt. of melted cast iron from a cupola furnace were then introduced, with sand and lime. During the reaction, fumes, first white, then brown, next gray, were evolved. A violent flame and a roaring noise attended upon it. When again tranquil, the metal

was emptied on the floor of the furnace; the slag ran out and the pasty mass was pressed between rollers. He was unable to tell the proportion of phosphorus in the slag. The crude cast iron employed contained 1.43 per cent, and the cast steel obtained under .3 per cent. A part, at least, of the phosphorus lost was certainly to be found in the slag.

Dr. Paul quite agreed with Mr. Forbes that Swedish steel was free from phosphorus. As far as he could learn, there was no other evidence in proof of the injurious action of phosphorus on steel.

DOES IRON IN BRIDGES DETERIORATE?

THE HAMMERSMITH SUSPENSION BRIDGE.

From "The Engineer."

A very interesting question has been put to the public in general, and to engineers in particular, by the Secretary of the Royal Humane Society, through the medium of the "Times." This gentleman has, it appears, remarked on the occasion of more than one boat race, that the pretty suspension bridge at Hammersmith is taken possession of by an excited crowd standing as close possibly as men can stand; and he has further perceived that on the passage of the contending boats beneath, this crowd surges from one side of the bridge to the other, and causes it to oscillate violently, as in the manner of suspension bridges on comparatively slight provocation. He has heard that in process of time iron crystallizes and becomes brittle under strain. He is aware that Hammersmith Bridge has been built a long time, and strained and shaken not a little; he fears, therefore, that the quality of the iron has been deteriorated; and dreading the consequence of the giving way of any portion of the structure during the approaching Oxford and Cambridge boat race, he wrote a very sensible letter to our contemporary, therein suggesting that the matter should be looked into a little. On Thursday week Lord Bury asked the Government, in the House of Commons, whether they intended to take any action in the affair, and was informed that the Board of Trade would send a competent engineer to examine and report upon the structure. Meanwhile one or two more letters have appeared in the "Times" on the subject, and notably one from the pen of Mr. G. Gordon Page, C. E.

It is not disputed that up to the present moment the bridge has proved itself to be strong enough to sustain any strain which sight-seers could put upon it. It has been densely crowded over and over again, and no important failure has ever taken place, nor have any but the most trifling repairs ever been needed. The assumption that an accident may follow if the public take possession of the platform on the 17th instant, rests simply on the theory that the molecular structure of the iron has been deteriorated by vibration under strain, or that the sectional area of some important members—such as the chains or the suspending links—has been reduced by corrosion. We must wait for the report of the Board of Trade engineer to settle these things. But, meanwhile, we may point out that the inquiry possesses peculiar interest, not only as regards Hammersmith Bridge, but all iron structures exposed to vibration while loaded. It has long been a vexed question among engineers whether iron does or does not become crystalline and brittle in service; and it will be no small achievement for the Board of Trade to advance our certain knowledge of the subject by the contribution of even one well verified fact. The controversy may be regarded as involving three different theories. According to one, iron invariably becomes brittle and crystalline under even the most moderate strains, provided it is kept in vibration for a sufficiently long period. According to another theory iron never becomes crystalline and brittle under any strain; and, according to the best, the metal changes its character only when strained above its limit of elasticity—that is to say, when it has been stretched to such an extent by any applied force that it will not, on the taking off of that force, return to its original dimensions. The second theory is now almost universally rejected as untenable by competent engineers. It is excessively difficult to prove which of the remaining two is right and which is wrong, for the following reasons: In the first place it is impossible to tell the exact strength of a bar without testing it till it breaks. Therefore it is not easy to determine whether any bar has been weakened by age and molecular change or not. We may try a bar now and find that it will stand eight or nine tons per square inch without permanent set. We may put this bar in use, test it at the end of twenty years, and find it stand just what it did before; but it by no means follows that this circum-

stance proves that no deterioration has taken place. To assume that the facts supported this latter theory, is to assume that the original test was as nearly as possible all that the iron would bear, so that no margin was left for deterioration, which might or might not be true; but it is as we have said, practically impossible to test, in the first instance, any bars used in a structure like the Hammersmith Bridge, right up to the last limit without going beyond it. In the second place it is difficult to prove that a bar has deteriorated by any examination of the structure. Those who believe in the deterioration under vibration theory, maintain that the iron loses its fibrous nature, becoming crystalline and brittle. The assumption of deterioration is based on the presence of a crystalline internal structure in the bar, which it is believed the bar did not originally possess. Now it so happens that we know less probably about the internal structure of iron than about that of any other substance used in the arts. We never see anything but its outside. Break or cut an iron bar as we will, still we are on the surface. Thus, as is perfectly well known, a bar 10 ft. long can be broken into ten pieces, showing alternately a fibrous and a crystalline fracture. Moreover, it does not follow that fibrous iron must be stronger or better than crystalline iron. It is quite true that rails, axles, chairs, etc., which have broken after long service, usually give a crystalline fracture, but it has never been proved that we are not confounding cause with effect when we say that the rail or the axle was broken because it had become crystalline. It may be just as correct to say that the rail had become crystalline because it was broken, for anything proved to the contrary. Of course we do not mean to assert that the structure of iron or steel does not change during use, or that these metals do not deteriorate in service, for this is contrary to fact. We only desire to point out that it has not been definitely proved that iron becomes crystalline when caused to vibrate under strain; or that, assuming crystallization does take place under such conditions, it follows that the iron has become weaker because it is crystallized. Whether it is brittle because it has changed to the crystalline from the fibrous condition, or whether it has changed from fibrous to crystalline because it has become brittle, no one can say with absolute certainty. The brittleness is demonstrable, the cause is not. It has been argued, indeed, and with some show of reason, that there is no such thing as congenitally fibrous iron, but that fibrous fracture merely results from the drawing out and rearrangement of certain previously interlocking crystals when the iron is broken under test, just as an apparently amorphous mass of felt may be resolved into its constituent fibers by careful carding. The theory is not ours, and we neither endorse it nor dispute it. We cite it simply to show that there is at least one way of reconciling difficulties connected with the appearance of the fracture of iron.

As regards the examination of Hammersmith Suspension Bridge, we wish it to be borne in mind that even should the test bars, which we suppose will be taken from the structure and broken, show a crystalline fracture, the circumstances will not prove molecular deterioration. Neither will the presence of a fibrous fracture prove that the structure is perfectly safe and trustworthy. The point to which the Board of Trade engineer should devote his attention, is the degree of elongation manifested by the bars before fracture. If this is not considerable, it may be taken for granted that the iron has deteriorated, whether the fracture is or is not crystalline, because the bridge was built almost before hot blast iron was known; and there can be little doubt that whether very strong or not, the materials of Hammersmith Bridge were well made and originally ductile in a very high degree. If the inquiry is properly conducted, its results will prove very valuable. The least carelessness will render them useless.

Mr. Page's letter, to which we have before referred, contains certain interesting statements worth reproduction. Quoting a report by Professor L. D. B. Gordon, dated August 7th, 1862, he writes: "Hammersmith Bridge was erected in 1827; Engineer, W. Tierney Clarke. Total length between land abutments, 710.7 ft.; useful width of road, carriage-way, 20 ft.; two footpaths, each 5 ft.; total width, 30 ft.; span of main opening, 422.5 ft.; ratio of versine to span, 1-14.31; the total section of chains at the towers, 180 square inches; weight of a superficial foot of roadway, 63 lb."

As a matter of fact the bridge was completed in 1824, not in 1827. Mr. Page goes on to say that "Drewry, an authority on suspension bridges, states that the bars of the chains were proved up to nine tons per square inch. The greatest possible load has

been assumed by Mr. E. Clark at 80 lb. per superficial foot, but this has been considered as excessive by many engineers. An experiment was made, which came under my notice, by packing men on a weigh-bridge, with a result of 84 lb. per superficial foot; but it is not within the limits of probability that such a crowd could accumulate on any bridge. I gather from various authorities that 70 lb. per foot superficial may be assumed as a standard for the load that the platform of a bridge could contain. Such a load on Hammersmith Bridge would produce a strain on the chains of 8.86 tons, or 1.4 tons below proof strain."

Inasmuch as the maximum strain now allowed by the Board of Trade is but five tons, it is evident that the structure is nearly 45 per cent weaker than these regulations allow; and we confess that we think the apprehensions—the expression of which has led to the official inquiry—are very well founded.

We cannot better conclude this article than by appending a few particulars regarding the construction of Hammersmith Bridge, in addition to those given above, by Professor Gordon. His dimensions are substantially correct. The deflection of the main chains in the centre is 29 ft. 3 in. The tension on the iron at the points of suspension is 1.857 times the entire suspended load. The piers are of stone, 22 ft. thick, 42 ft. wide at the top, 72 ft. at the waterline, and 48 feet high, measuring from the carriage road. There are eight main chains, arranged in four double lines, two small chains being put one under the other on the outside of each footpath, and two principal chains on each side of the carriage way. The small chains each consist of three rows of 1 in. flat bar links, 8 ft. 10 in. by 5 in. wide, coupled by 2¾ in. round bolts, and covering plates 15½ in. long by 8 in. broad and 1 in. thick. The large chains consist each of six similar rows of plate links. The vertical rods are 1 in. square, and stand 5 ft. apart.

THE ELLERSHAUSEN PROCESS.—Some very careful experiments have recently been made at one of our large ironworks. In order to test several kinds of iron, and to determine the waste with accuracy, the iron was melted in a cupola and afterwards weighed. Several varieties of ore were used. Analyses of the material at different stages are being made. We shall publish the results.

AMERICAN LOCOMOTIVES AND ROLLING STOCK.

From a paper by Zerah Colburn, before the Institution of Civil Engineers, March 9th, 1869.

In construction and working, the American railways represent little more than a modified application of English practice. When the systems of the railway machinery of the two countries are compared, many of the differences which first strike the eye are found to be external, rather than fundamental; and so, too, many of the peculiarities of construction now retained in America are due to the initiative of English engineers.

Pursuing the history of the introduction of locomotives into the States, it was observed that the first two worked in America were made in England in 1828, one by Mr. George Stephenson, the other by Mr. J. U. Rastrick. In the same year the engineers of the then contemplated Baltimore and Ohio Railroad visited this country, when Mr. Robert Stephenson suggested to them what was now the distinguishing feature of all American railway rolling stock, viz, the bogie, to be applied to the engines intended to work round curves of six chains radius, at that time proposed to be adopted. The bogie, which had grown out of William Chapman's invention of 1812, was then, Mr. Stevenson stated, in regular use upon the quays of Newcastle. Having regard to the character of the lines first constructed in the States, it was essential that the locomotives should be light and cheap, and the first engines made there, between 1830 and 1832, weighed only from three and a half tons to four tons. Some of the English-built engines imported at about that time had their leading wheels removed, and a swiveling bogie substituted. The bogie was not, however, exclusively employed. Considerable numbers of engines made by Messrs. Stephenson & Co., Messrs. Bury, Curtis & Kennedy, Messrs. George Forrester & Co., and Messrs. Braithwaite & Co., were afterwards imported, and worked as originally constructed; and, as late as 1855, at least one hundred locomotives of English construction, or made almost exactly upon Messrs. Stephenson's plans, could have been counted at work in the States. For many years wood only was employed as fuel, and as it produced great quantities of sparks, as annoying to passengers as they were dangerous to goods, much ingenuity was directed to the problem of separating and withholding them from the escaping smoke and steam; and the

voluminous "spark arresters" were very successful in this respect, while they gave an individuality to the engines. Again the rigor of the American winters compelled the adoption of some kind of shelter for the enginemen and firemen; and this was afforded by the bulky, and often extravagantly painted "cabs," which imparted a novel appearance, but without in any way affecting the principles, or economical conditions of working, of the engine.

As high speeds were seldom attempted upon the early American lines, the greatest steam tractive power was sought and obtained, both by working high pressure steam and by employing driving wheels of small diameter. Thus, although, in 1835, the English built engines, and those copied from them, were worked at 50 lb. pressure, and had 5 feet driving wheels, it was not long before American practice settled upon 90 lb. to 100 lb. pressure and 4 ft. or even 3 ft. 8 in. driving wheels. It was soon found, however, that the adhesion weight upon a single pair of wheels, necessary to work up this increased steam tractive force, was too great for the strength of the way, and coupling was then resorted to; and now, with the exception of a few light tank engines on branch lines, there was not probably an engine in the States having single or uncoupled driving wheels. Four tons might be said to have been the maximum per wheel for many years, while three tons was the more usual average.

Compensating levers were now employed on all American engines, whereby the weight was not only equalized between the coupled wheels, but the effect of a jolt upon one pair was divided and distributed, through the springs and levers, upon the other pair. For some years, too, bearings of the outer ends of the springs of the coupled wheels were made to rest upon india-rubber blocks.

The details were then given of several descriptions of engines long worked on the Baltimore and Ohio and Reading railroads, as well as of those employed to work the incline of 1 in 16½ and 1¼ mile long, at the Madison terminus of the Madison and Indianapolis railway. Compared with English practice, in which six-wheeled coupled engines had from 5 tons to 6 tons on a wheel, and eight-wheeled coupled engines had 7 tons on a wheel, it was observed that the subdivision of weight in American engines was carried about half as far again, or, in other words, that they averaged only about two-thirds as much weight per wheel, and that they thus required, for a given total weight, half as many more wheels. Except with smaller wheels, this could not be done on any practicable length of wheel base; but none of the American goods and bank engines, of which the particulars had been given, had wheels larger than 3 ft. 11 in. in diameter. There were objections also, of much weight, to coupling a larger number of wheels from a single pair of cylinders. It was more or less difficult, if not impossible, to preserve an exact equality in the diameter of the wheels, an exact parallelism of the axles, and exact equality in length of the coupling rods. The extent to which coupling had been carried in American goods engines had been due, in a great measure, to the following expedients. The coupled wheels were as equally loaded as possible; their tyres, in a majority of cases, were of chilled cast iron, since replaced by steel; and the former were cast, and the latter turned, nearly or quite to a cylindrical form, or with but little or no cone. The driving wheels were the middle pair, or, in the case of an even number of pairs, one of the pairs nearest to the mid-length of the wheel base; compensating levers were employed, and adjusting wedges had for some years been applied to the axle-boxes. The coupling rods, in many cases, were made without brasses, round steel bushings being fitted to circular eyes formed at the exact required distance apart in the ends of the rods. With the exception of the leading and trailing wheels, the coupled wheels were generally fitted with plain cylindrical tyres having no flanges. Outside coupling cranks, necessary with outside frames, had rarely been employed, and were never so now. The coupling rods were counterweighted within the wheels themselves, no attempt being made, in inside cylinder engines, to set off their weight against that of the cranks and attached parts. In other words, the coupling pins of the driving wheels were coincident, on each side of the engine, with the position of the crank in inside cylinder engines, and, of course, necessarily so in outside cylinder engines. The experience of American locomotive engineers had been to the effect that with this arrangement, which was the opposite of English practice, the axle-boxes wore more uniformly, and that there was less "knocking" where a little play in the horn plates had once begun. And lastly, the length of the crank being one-half the radius of the small coupled wheels employed,

any inequality in the length of the coupling rods was attended with less slipping and binding than where, with larger wheels, the crank was but about one-third the radius of the wheel.

The general form of passenger engine now in use in the States was then described. It had in most cases outside cylinders—indeed, inside cylinders had not been built for many years—and it had invariably four coupled driving wheels and a four-wheeled bogie. The leading dimensions of the representative type of passenger engines were: cylinder from 15 in. to 17 in. in diameter, with a length of stroke of from 22 in. to 24 in., and coupled driving wheels of from 5 ft to 5 ft. 8 in. in diameter. Such engines would exert a tractive force of $3\frac{1}{2}$ tons to 4 tons in starting, for which their adhesive weight, assisted sometimes by sand, was sufficient; and thus they could get quickly away from stations, even with trains of a gross weight of 200 tons or more. Economy of fuel had not been studied to the same extent in American as in English locomotives: the blast pipes of the former were smaller, the draught more forced, the back pressure greater, and less expansion was attempted in the cylinders, the link motion being generally arranged to cut off at one-third stroke as a minimum, and at nine-tenths, or more, as a maximum. It was thus that boilers of moderate size were made to supply steam for work equal to 300 indicated horse power, or the exertion of upwards of 2 tons of draught upon a passenger train at a mean speed of 25 miles an hour; but there was nothing remarkable in the consumption of from 50 lb. to 60 lb. of coal per mile in such work. It was stated that on the Pennsylvania Central railroad—a line 356 miles long, with gradients of 1 in 100 and 1 in 55—the consumption of coal for both goods and passenger trains amounted on an average to about 70 lb. per train mile, the goods mileage being three and a half times the passenger mileage. The coal was of excellent steaming quality, and cost about $3\frac{1}{2}$d. in currency, or $2\frac{1}{2}$d. in coin, per train mile. At this rate a difference in consumption of 24 lb. of coal per mile would only cause a variation of 1d. per mile in the cost of fuel; and it had been argued that such a waste was better than the alternative of employing an engine 4 tons or 5 tons heavier, to work with a less rapid rate of combustion, a slower piston speed, and more expensively.

The goods engines were moderate in weight, had large cylinders and small wheels, and drew heavy trains at a fair speed, with a consumption of coal often amounting to 100 lb., or more, per mile. On the Pennsylvania Central railroad the standard type of this class of engine had ten wheels, of which six, each 4 ft. 6 in. in diameter, were coupled. The whole weight of the engine was only $31\frac{1}{8}$ tons, and of this but $23\frac{1}{2}$ tons rested on the coupled wheels, available for adhesion. The cylinders were 18 in. in diameter, with a length of stroke of 22 in. With 60 lb. mean effective pressure per square inch upon the pistons, those engines would exert a tractive force, less their own internal resistances, of rather more than $3\frac{1}{2}$ tons, or about one-seventh their adhesion weight, although in starting a train, or in ascending a gradient, with 100 lb. pressure on the pistons, the steam tractive force would be 6 tons, equal to more than one-fourth of the adhesion weight, the efficiency of which would then be assisted, when necessary, by sand. Details of the performance of some of these engines were next given. In one case, after allowing for gravity $8\frac{5}{8}$ lb. per ton, for a train, engine and tender included, of 1,040 tons weight, the total resistance would be 4 tons, and thus the work done on each mile was calculated to be equal to 24 horse power exerted for one hour; and if the estimates could be trusted, the consumption of coal per horse power per hour would not exceed $4\frac{1}{4}$ lb. to $5\frac{1}{4}$ lb. The speed probably was not more than 15 miles an hour, corresponding to 360 horse power. The policy of American railway managers, with respect to goods traffic, as it was also the policy of the managers of most of the French lines, was maximum loads at slow speeds, involving a minimum resistance per ton, and correspondingly a minimum working expenditure per ton.

No experiments upon the dynamical efficiency of American engines had been made, so far as the author was aware; but he had run an experimental train on the Erie railway, over the whole length of the line and back, a total distance of nearly 900 miles. The same engine was employed throughout the run, occupying in all nearly three weeks, making an average for each week day of about fifty miles. The results of these experiments appeared to show, that the resistance of bogie rolling stock, even under disadvantages, was less than that of English rolling stock, as ascertained by the best authorities, and also that the rate of adhesion

to weight averaged considerably more in the States than in England. With respect to adhesion, as the surfaces in contact were identical with those on English railways—indeed the rails and tyres in general use in the States were commonly of English manufacture—any difference in this respect must be attributed partly to the influences of climate and partly to a better application of sand, when necessary to increase the bite upon the rails. The sand was dropped equally upon both rails, not in intermittent handfuls down a pipe on one side of the engine only, but by means of the hand gear and regulating valve since adopted on the North London Railway. The experiments in question were, no doubt, influenced by the favorable circumstances of weather, and something was to be allowed also for the great length of train drawn, very long trains having a less tractive resistance per ton on a level than short ones, and something, possibly more than was commonly supposed, might have been due to the use of oil-tight axle-boxes, the saponaceous compound known as "railway grease" being nowhere in use on railways in the States. Messrs. Guebhard and Dieudonné's experiments, made in 1867, on the Eastern Railway of France, showed a considerable diminution in the resistance of oil-boxed rolling stock, as compared with that fitted with grease boxes.

Of the mechanical details of American locomotives, considered apart from the details already touched upon, much might be said. There were differences, and they were numerous, but they involved no important principles. The chilled cast-iron wheel, however, for engine and tender bogies, and especially for carriages and wagons, deserve mention. No wrought iron wheels, so far as the author could learn, were now employed in the States, unless in a few cases for engine driving wheels; and wrought iron wheels, at first exclusively adopted, had been wholly abandoned on the Grand Trunk and the Great Western railways of Canada. The cast iron wheels were not only much cheaper, but they were more durable, and, if not safer, were at least equally safe. The wheels employed for passenger carriages were 2 ft. 9 in. in diameter, and weighed 5 cwt. The bogie wheels of engines, tenders, and goods wagons were generally 2 ft. 6 in. in diameter, and varied in weight from 4 cwt. to 4½ cwt. They were cast of special mixtures of the best qualities of iron, the requisite conditions being great absolute strength to resist both sudden and progressive strains, and the property of taking a deep and uniform chill. But little of the cast iron employed for wheels had a tensile strength of less than fifteen tons per square inch, and it broke with a fracture, almost suggestive of fiber, and of a dark gray color, but when chilled of a silvery whiteness. The chilled wheels ran from two to six and even seven years, according to the traffic, before becoming so much worn as to require removal, representing a service of from 80,000 miles to 200,000 miles. Engine driving wheels of from 4 ft. to 5 ft. in diameter, had been cast with chilled faces, thus requiring no tyres, and chilled tyres, from 4 ft. to 6 ft. diameter and 3½ in. thick, had been extensively and successfully employed at fair rates of speed, say 28 miles an hour.

Wood was almost exclusively employed as fuel, except upon two or three important lines in the coal districts, until within the last ten or twelve years. Iron fire boxes and copper tubes were then generally adopted; but for burning coal, steel fire boxes and iron tubes were now used. Of upwards of four hundred steel fire boxes in the engines of the Pennsylvania Central railway, some had been in use for six years or more. The tubes were set without ferules, and very little trouble, as the author was informed, was experienced either from leaking or cracking. It was worthy of observation, that the evil of "furrowing," by no means uncommon in this country, was unknown in the States, and no other explanation appeared available, than that the thinner iron employed there permitted of a certain elasticity in the structure of the boiler, sufficient to prevent the localization or accumulation of bending or other strains at particular points, or rather upon particular *lines* of resistance.

What were now understood as steep, or exceptionally steep, gradients were rare in the States. Some instances of such were cited, and it was mentioned that, in July, 1836, one of Norris' engines, weighing 6 tons 8½ cwt., and drawing behind it, including tender, a load of 8 tons 11½ cwt., ascended an incline near Philadelphia of 1 in 14, and 933 yards long, at an average speed of 15¾ miles an hour. The nominal weight on the driving wheels was 3½ tons, but it was believed that a portion of the weight of the tender was made to bear upon the foot plate, thus increasing the adhesion.

With regard to the expense of maintenance, it was stated that the average cost of

engine repairs in the States, exclusive of those renewals which amounted to building a new engine, might be taken as a maximum at 10 cents currency per train mile, equal to 3¾d. in coin. Of this, the absolute difference in the cost of labor and materials would account for nearly or quite 1d., leaving 2¾d. to 3d. as the cost at English prices. Again, the manner in which these repairs were conducted showed a want of system and organization, and the shops were not fitted with some of the appliances considered essential in this country. Whatever economy in repairs might attach to the American engines was due, after allowing for the moderate working speed, to three causes only, viz: the use of the bogie, of chilled cast iron bogie wheels (which could be renewed at a cost of from £2 to £2 10s. each, after allowing for the value of the wheel taken out as old iron), and of steel or iron fire boxes and iron tubes. About twelve or fifteen years ago, the average mileage of American engines, taking the full stock of the leading lines, was not above 15,000 miles yearly—now it was probably not far short of 20,000 miles, and on some lines it might be even more.

There remained the consideration of the carriage and wagon stock, with reference to its mechanical peculiarities and its commercial relation to traffic. The earlier American carriages were made upon the English model, but it was found not only that a short wheel base was required for six chain and nine chain curves, but also that side buffers aggravated the difficulty. The bogie, already in use on the engines, was, therefore, adopted for the carriages, and it was soon discovered that the length of body could be considerably increased, and that the longer it was the steadier it became. But the long bodies precluded the use of side buffers, and so the central buffer with a loose coupling took their place. End doors afforded an obvious means of economy in the structure of the carriage, and left the whole depth of the body below the window sills available for any combination of trussing, most effective for carrying out a comparatively long span. The end doors, with a continuous passage throughout the carriage, afforded obvious facilities for communication. The central passage required an additional width of carriage, and from 9 ft. to 9 ft. 6 in. was a common outside width; while in some cases, even on the narrow gauge, a width of more than 10 feet had been adopted. These widths allowed seats for four passengers across, and for the longitudinal passage dividing the seats. The seats had reversible backs, so that the passenger might face either way, the carriages running in either direction without turning. It was undeniable that the seating was not so roomy and comfortable as in an English first-class carriage, and that, as compared with a second-class carriage, there was a certain loss of space. It was equally undeniable that such carriages could never answer for short traffic lines, where forty, fifty, or more passengers had to leave, and as many more to enter, in a minute or a minute and a half. The long body, however, with end doors and platforms, possessed obvious mechanical advantages. Its length gave steadiness, and the depth below the window sills afforded ample opportunity for providing vertical stiffness without undue increase of weight. There were no cross partitions; there were but two doors where English carriages would require, for the same number of seats, according to class, from twelve to twenty-six; there was much less sash and glazing, while there was at the same time more light; there was an important saving in respect of draw-springs, buffers, buffer-rods and screw couplings, and there was every facility for applying brakes, as was always done in the States, to every wheel in the train, either from the platforms of the carriages themselves or from the engine. It was an advantage of the long body, with its corresponding weight and number of wheels, that the application of the brakes, however suddenly, did not produce the jolting of which passengers complained so much when the same thing was attempted upon English carriages. Passenger carriages upon the double bogie plan were made of various lengths, from 45 ft. to 60 ft. exclusive of the additional 2 ft. 6 in. at each end for platform and covering porch. They accommodated from sixty to eighty-four passengers, and weighed, empty, 12 tons and upwards, or from 16 tons to 22 tons loaded. Some notice was next given of Pullman's hotel car, and of the carriage built by the Messrs. Winans for the Emperor of Russia. The improvements which had been effected in the engine and other bogies were then alluded to, and a description was given of the oil-tight axle-box, as well as of Loughridge's and of Creamer's continuous brakes.

In comparing the cost of maintenance of American carriage and wagon stock with that on English lines, many considerations were to be regarded. To say that the cost, in

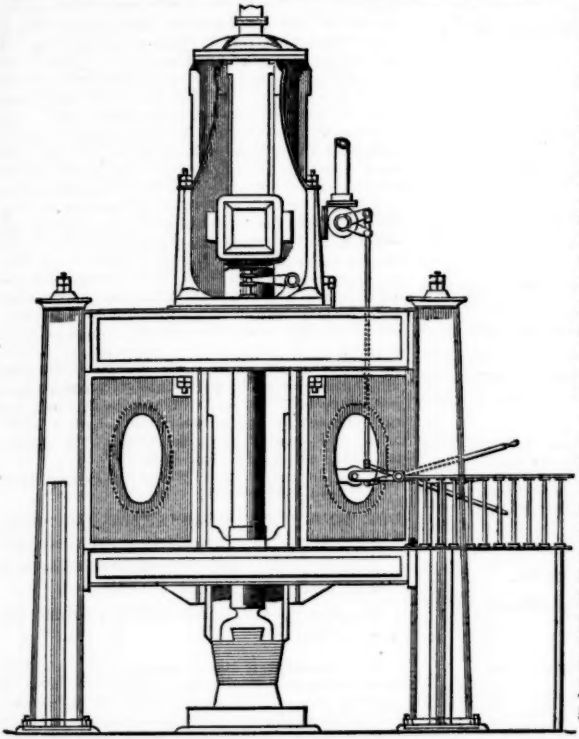
1867, on the 1,612 miles of railway in the State of Massachusetts, for a train mileage of nearly ten million miles, was 6.55 cents currency, or about 2½d. coin, per train mile, did not permit of any accurate deductions. In the States, the average number of passengers continuously carried over the whole distance made by a train was generally one-half greater than in England, although the proportion of dead weight to live load was probably nearly as high as in this country; the speed was less, and there remained the fact that labor and nearly all materials were much dearer. On the other hand, there was a considerable saving in the use of chilled cast iron wheels, such a thing as a wheel-turning lathe, for carriage or wagon stock, being unknown in the States; the maintenance of buffer and draw springs cost much less; the maintenance of the carriage bodies was cheaper, from their greater strength and simplicity of structure, and from the fact that there were no side doors to slam.

One objection to the use of chilled cast iron wheels, not referred to in the earlier portion of the paper, was that, being almost necessarily of the disk form, their weight increased in a ratio nearly as the square of the diameter, and thus the largest railway carriage wheels yet employed in the States were but 3 ft., and this size was long ago discontinued in preference for 2 ft. 9 in. In the case of cast iron spoked wheels, the chill was less hard opposite the ends of the spokes than elsewhere, and thus they soon showed flat spots.

It might be said, in conclusion, that if American railway practice were in any or many respects more daring than that which prevailed in this country, failure, if not too often repeated, was regarded in the cousin country as a misfortune, where here, unless it proceeded from causes absolutely beyond prevision, it was rightly regarded as a fault, a misdemeanor, or even a crime.

THE RAILWAY FERRY ON THE LAKE OF ZURICH.—The "Neue Zürcher Zeitung" gives some farther particulars of the work, which was generally described in "Van Nostrand's Magazine," No. III, page 208.—When the idea of a steam ferry was adopted, Mr. John Scott Russell, civil engineer and naval architect, was charged with making the necessary designs for it. Mr. Russell built, twenty years ago, the first steamer put upon the Lake of Zurich for the steamboat company at Schaff'hausen, and this steamer is considered up to the present day as one of the best crossing that water. The contract for the execution of the ferry boat was entrusted to Messrs. Escher, Wyss & Co., of Zurich, after a competition with several of the first class firms of England, France, Germany and Switzerland. The work was begun in January, 1868, at the works of the abovenamed firm at Stampfenbach, and the ferry boat was launched in the following October. For its propulsion a steam engine of 200-horse power (nom.) is employed. The fixed works required at the two ports, including two steel bridges (also designed by Mr. J. Scott Russell), in order to establish a direct communication between the shore stations and the ferry boat, had already been executed in Friedrichshafen under the direction of Mr. Brockmann, engineer of the Wurtemburg Railway, and in Romanshorn, under the direction of Mr. Seitz, engineer of the North Eastern Railway of Switzerland. These steel bridges are fixed at one end, which is on the same level as the rails in the stations, whilst the other end can freely move up and down in order to correspond with the level of the rails upon the boat, as conditioned by the different heights of the water of the lake, which varies at different seasons. These bridges and the ferry boats are provided with two lines of rails in order to carry at the same time two trains across the lake. The ferry boat itself is constructed strong and stable enough to resist even the most violent storm; its bottom is flat, and its upper works are partly covered in by a roof, which forms also a deck, from which the captain directs the course, and which may be also used by the passengers of the railway trains as a pleasant lounge during the passage. The time of crossing the lake is about one hour, and there exists no reason why other lakes in Switzerland, many of which are 50 to 60 kilometers long, should not be crossed in the same manner. The working expenses of such a system are not higher than those of a first-class railway, and the velocity may be increased from 20 to 25 kilometers per hour. The lakes would thus no longer constitute a severance between two districts or countries, but would become highways for increasing the traffic and for facilitating the communication.

We are glad to find, says the authority quoted, that Mr. John Scott Russell's abilities, which his countrymen, at least those of the world of science, cannot forget, thus appear to continue to find useful and congenial application.



FIFTEEN-TON STEAM HAMMER FOR THE RUSSIAN GOVERNMENT.—The engraving represents a so-called "50-ton" double-action steam hammer, which has been constructed by the Kirkstall Forge Company, Leeds, to the order of the Russian Government. The hammer frame, as will be seen, is, with the exception of the cylinder, constructed entirely of wrought iron plates. The valve gear is so arranged that the hammer can be driven at either side. Steam is admitted to the cylinder by an equilibrium slide valve, a conical valve being fitted into the upper passage, admitting either the exhaust steam from the under side of the piston, or the full pressure from the boiler to the top side when required, so that the hammer may either fall by its own gravity with the pressure of exhaust from the underside of piston added, or the blow is increased by the admission of full steam from the boilers. The piston and rod are forged in one piece, which, together with the hammer, weigh 15 tons. The cylinder is 46½ in. diameter and 8 ft. stroke.—*Mechanic's Mag.*

LARGE HYDRAULIC TESTING MACHINE.—Messrs. William Sellers & Co. constructed, some seven years since, a testing machine for the Pennsylvania Railroad Co., after the designs of J. H. Linville, Esq., President of the Keystone Bridge Co. The following are the principal dimensions: Piston, about $18\frac{3}{16}$ diameter; 260 sq. in. area; stroke, 2 ft.; thickness of ram about 9 in. The machine is mounted on a foundation of masonry 75 ft. in length. In front of the ram, and 29 ft. from the cross head, which is mounted on wheels and propelled by the piston, is another fixed cross head, coupled to the ram by 12 bars of iron 7 in. × 1 in. At this end of the machine, by use of differential blocking pieces, any sized specimen, up to 3 ft. diameter and 28 ft. in length, can be subjected to a pressure of 675 gross tons.

To the cross head in front of the piston is coupled a similar cross head, mounted on wheels in rear of the ram. Compression beams, 4 ft. in length, are secured to the masonry, with a movable cross head secured in notches in the compression beams. This end of the apparatus is used for testing large bars, to determine their tensile strength, and is now coupled to the forward cross head by bars proportioned to withstand a tensile stress of 130 gross tons. The pumps are double acting, with large and small piston for light and high pressure. The machine is supplied with two of Shaw & Justice's mercury gauges, and two spring gauges, also a weighing lever. For the last two years this machine has been in use at the Keystone Bridge Works and Union Iron Mills, Pittsburg, where the iron for all the Keystone Company's bridges is tested. The machine described in this Magazine (No. 4, page 346) is not, therefore, the largest in the country, and is similar to, but smaller than the machine, above described, which has been in constant use for seven years.

HISTORY OF DECARBURIZING IRON.

No. III.

The titles only of letters patent of the United States, prior to 1848, are published. No other information regarding these patents is accessible, except at the cost of manuscript copies from the Patent Office. After 1847, the claims of United States patents are also published. From 1855, engravings (such as they are), illustrating specifications, are published, and later still, abstracts of patents appear in the Patent Office reports.

There were only thirteen United States patents referring to the decarburization of pig iron, issued by the United States prior to 1847. Of these, four were prior to the date reached in our former article (1836), and are mentioned below.

Such matter as is accessible, regarding the United States patents after these dates, will be compiled in chronological order, for the present series of articles.

STEEL FROM PIG IRON.

LEONARD, ENOCH, Canton, Mass.—1812. January 16.

MALLEABLE IRON FROM PIG.

LEWIS, THOS. C., Pittsburg, Pa.—1830. October 1.

PUDDLING AND HEATING IRON.

JONES, WM., Haverstraw, N. Y.—1833. December 16.

PRESSING OUT PUDDLE-BALLS INSTEAD OF HAMMERING THEM.

JONES, WM., Haverstraw, N. Y.—1834. April 18.

PURIFYING CRUDE IRON IN THE FINERY AND IN THE PUDDLING FURNACE, BY MEANS OF DEFINITE PROPORTIONS OF CHLORIDE OF MANGANESE, BICHLORIDE OF CALCIUM AND CHARCOAL.

DUCLOS, EDWARD FRANCIS JOSEPH.—1837. October 20. No. 7,448.

Manufacturing iron. The invention consists in combining with "cast iron and its scoria, while they are in a state of fusion," metallic chlorides (as of manganese and calcium), whose bases combine with the iron and slag, while the chlorine combines with the volatile impurities, such as sulphur, given off by the iron. Both of these combinations are said to produce a beneficial effect upon the iron, and produce an alloy equal to malleable charcoal iron. The specification and drawings describe a refinery furnace having a crucible. About 30 cwt. of cast iron are introduced into the furnace when it is at a white heat, and immediately afterwards 336 lbs. of dry chloride of manganese, and 63 lbs. of bichloride of calcium or "bleaching powder," are put into the crucible. Over the mixture is put a layer of wood charcoal two or three inches thick, and over that a layer of scoria, of like thickness, mixed with sufficient quicklime to combine with the free silica contained in the scoria. The whole is then melted, and the surface of the metal is again covered with wood charcoal. "The usual tools for working the metal are then introduced," and during the working portions weighing ten pounds each of the chloride of manganese and bichloride of calcium, are thrown in at intervals. The surface is to be kept covered with charcoal, and in half an hour the refined metal may be run out. It is then puddled, and during that process the chlorides must be added at intervals, in proportions of about one per cent of the weight of the metal. The bridge of the puddling furnace is made double, and the space between is filled up with charcoal. When the slag has been run out, and the metal brought to nature, in order to free it from all silicious impurities, it is submitted to the action of a charcoal fire.

[Printed, 5d. See "London Journal" (Newton's), vol. 12 (conjoined series), p. 345.]

ORE AND LIME SUBSTITUTED FOR HAMMER SLAG IN PUDDLING—REFRACTORY STONE USED FOR PUDDLING FURNACE BOTTOMS.

GOSSAGE, WILLIAM.—1838. June 18 No. 7,693.

Manufacturing iron. A cheap material is used as a substitute for "hammer slag" in puddling pig or crude iron. Argillaceous ironstones calcined and powdered small are introduced into the puddling furnace with the pig iron, either alone or mixed with powdered lime, quicklime, or carbonate of lime. The proportions required vary according to the qualities of the ores; about 450 lb. of pig iron, 30 lb. of calcined iron ore, and five pounds of slaked lime, are beneficial proportions. If the cinder does not separate easily, more lime should be used, and if the metal does not sufficiently "boil up," more powdered ironstone should be added. Also, instead of cast iron for the bottoms or soles of puddling furnaces, grit stones or other fire-resisting stones slightly hollowed to receive the charge, are preferred and claimed.

[Printed, 4d. See "London Journal" (Newton's), vol. 15 (conjoined series), p. 445; vol. 17, p. 329; also Patent No. 6,908.]

FURNACE—REFINING IRON.

SHARP, JAMES, Liverpool, Pa.—1838. June 23. (U. S.)

NOTE.—*No specification published.*

USE OF TAP CINDER IN PUDDLING.

BRADLEY, RICHARD; BARROWS, WILLIAM; HALL, JOSEPH.—1838. August 21. No. 7,778.

Making iron. The invention consists in the use of "tap cinder" obtained from puddling crude iron, instead of the cinder obtained from puddling refined iron, as a protection for the bottoms and sides

of puddling furnaces. Tap cinder is a cheaper substitute. It is prepared by breaking it in pieces about six inches in diameter, and roasting it gradually for about eight days in a kiln like a brick-kiln, which is fully described in the specification and drawings.

[Printed, 9d. See "Repertory of Arts," vol. 11 (new series), p. 149; and "London Journal" (Newton's), vol. 21 (conjoined series), p. 343.]

PRODUCING PURE CARBURET OF IRON — DECARBURIZING BY MALLEABLE IRON OR METALLIC OXIDES, SUCH AS CHROME OR IRON ORE—USING OXIDE OF MANGANESE IN PUDDLING—USING CARBURET OF MANGANESE IN MAKING CAST STEEL.

HEATH, JOSIAH MARSHALL.—1839. April 5. No. 8,021.

"Improvements in the manufacture of iron and steel." The specification describes and claims the invention under four heads.

1st. The extraction from "pure native oxides and carbonates of iron" of pure cast iron, without the intervention of flux or the production of cinder.

2d. Formation of cast steel by fusing the said pure cast iron with malleable iron or metallic oxides, in such proportions as to decarburate the iron to a certain degree, and by completing the decarburation in a suitable cementing furnace.

3d. The use of a certain portion of oxide of manganese in the process of converting cast iron into malleable iron by puddling.

4th. The employment of carburet of manganese in preparing an improved cast steel.

Under the first head the operation of producing pure cast iron is described. A blast furnace is filled with coke, charcoal or other equivalent fuel, and thoroughly ignited. The furnace is then first charged with twenty pounds of the pure ore to 100 pounds of fuel. Other charges are added at intervals, and the proportions of the ore are gradually increased at every charge, until they amount to 65 or 70 pounds of ore to 100 pounds of fuel. The ore is to be broken small to the size of peas, and will produce about 50 pounds of pure pig iron for every 100 pounds of fuel. The metal should be run into iron moulds. The metal produced is pure carburet of iron. This is converted into steel of any requisite hardness, by melting it in a cupola, with coke free from sulphur, or wood charcoal, using no more fuel than will just melt the iron, and burn away the carbon it contains to a considerable degree. The carbon is further "neutralized or removed" by adding scraps of metallic iron, or oxides of iron or of manganese, "taking care not to decarburate the metal to such a degree as to render it infusible, but to leave about as much carbon as exists in cast steel." To produce a superior cast steel "sesquioxide of manganese or peroxide, which had been previously ignited," should be employed. Sometimes oxides of chrome or iron are used. The steely metal so produced is run out into cast iron molds, and the ingots are "converted into steel of any requisite degree of mildness, by a further process of decarburation," by cementing it with peroxides of iron, or of manganese without charcoal in a cementing furnace, the period to which the metal is subjected to the heat being proportional to the degree of mildness required. The quality of malleable iron is improved by introducing from one to five per cent of pure oxide of manganese into the puddling furnace with the iron without mixing any other substance with it.

4thly. An improved quality of cast steel is formed "by introducing into the crucible bars of common blistered steel broken, as usual, into fragments, or mixtures of cast and malleable iron, or malleable iron and carbonaceous matter, along with from one to three per cent of their weight of carburet of manganese," and melting the charge, and pouring it into molds in the usual manner.

[Printed, 4d. The duration of the patent was prolonged, by an application to the Privy Council, for seven years. See for an account of the application for prolongation, and for reports of the ten various legal proceedings, Webster's P. C., vol. 2, p. 213 et seq. See also "Repertory of Arts," vol. 16 (new series), p. 101; "London Journal" (Newton's), vol. 15 (conjoined series), p. 221; also vols. 24, 26; "Mechanics' Magazine," vol. 39, p. 308; vols 42, 58; and other publications relating to patents and legal reports. See Patents Nos. 2,363, 3,697, 4,397, 6,837, 7,448, 7,762.]

NOTE.—*This is one of the most notable patents on record. The great value of using manganese in crucible steel making, which enabled British steelmakers to compete with foreigners and to use British irons to a certain extent, was here first pointed out by Mushet. But the British steelmakers managed, after many hard legal fights, to use manganese in a manner not strictly infringing Mushet's patent, and thus to rob him of all share in the profits that really grew out of his invention. This department of the patent will be considered in another series of articles. The compiler of the abstracts of the British specifications says: "This patent has been the subject of ten legal judgments, and been contested in every superior court in Great Britain. The most important feature of the invention lay in the discovery, by Mr. Heath, of a method of employing oxide of manganese in the manufacture of iron and steel beneficially, and with the certainty of controlling its powerful pernicious properties by the counteracting influence of carbon exposed to it in the requisite proportions."*

The features of the invention relating to the decarburization of iron, are the use of malleable iron scrap and the ores of iron, chromium and manganese. Employing malleable scrap for this purpose was specified by John Wood, in 1761 (see Van Nostrand's Magazine, No. 3, p. 194). The use of ore in puddling was more fully specified by Mushet, in 1835 (see Van Nostrand's Magazine, No. 4, p. 361). The present patent refers to the use of these substances in a cupola, for the production of a sort of decarburized pig iron to be further decarburized into steel.

The employment of chrome is first specified in this patent. Its function here is obviously that of a flux.

THE USE OF STEAM IN THE FINERY OR PUDDLING FURNACE.

GUEST, Sir JOHN JOSIAH, and EVANS, THOMAS.—1840. May 28. No. 8,518.

"Improvements in manufacturing iron," &c. The invention consists in introducing steam into the refinery or puddling furnace, "forced upon, or into, or in contact with the metal. Any suitable means may be employed. The specification and drawings describe furnaces having telescopic injection tubes.

[Printed, 9d. See "Repertory of Arts," vol. 16 (new series), p. 281; "London Journal" (Newton's), vol. 21 (conjoined series), p. 447; "Mechanics' Magazine," vol. 33, p. 381; "Inventors' Advocate," vol. 3, p. 23; and "Engineers and Architects' Journal," vol 3, p. 396.]

NOTE.—*This is the first mention of the use of steam in connection with the purification of iron.*

PUDDLING FURNACE — PUDDLING WITH ANTHRACITE COAL.

COOPER, THOS., New York.—1840. Aug. 25. Reissued.—1841. March 18. (U. S.)

NOTE.—*No specification published.*

THE FINERY AND PUDDLING FURNACE CONNECTED, SO AS TO RUN LIQUID METAL FROM THE FORMER INTO THE LATTER.

BOOKER, THOMAS.—1841. Feb. 22. No. 8,855.

"Improvements in the manufacture of iron." These consist in making a connection between the finery and the puddling furnaces, which may be of any suitable construction so that "the heated metal from the refinery furnace" may be run or passed into the puddling furnace, without being first permitted to cool.

[Printed, 9d. See "Repertory of Arts," vol. 17 (new series), p. 27; "London Journal" (Newton's), vol. 21 (conjoined series), p. 107; "Mechanics' Magazine," vol. 35, p. 208; "Inventors' Advocate," vol. 5, p. 134; "Transactions of Society of Arts," vol. 54, p. 25; and "Engineers and Architects' Journal," vol. 7, p 76.]

THE FINERY AND BOILING PROCESSES AT ONE OPERATION.

POWELL, LANCELOT, and ELLIS, ROBERT.—1841. April 24. No. 8,935.

"Improvements in manufacturing iron." The construction and operations of the refining, puddling and boiling furnaces are described as known before the date of the patent. The improved process consists in bringing iron, while in a molten state, from the blast furnace direct to the boiling furnace, and there subjecting it to the action of streams of blast or atmospheric air directed upon the metal while the boiling process is going forward. With a charge of four and a half hundredweight of iron (from Welsh ores) a stream of air introduced through "a pipe of one inch diameter, with a pressure of one and a half to two pounds on the square inch, leads to a beneficial result."

[Primed, 4d. See "London Journal" (Newton's), vol. 21 (conjoined series), p. 33; "Mechanics' Magazine," vol. 35, p. 366; and "Inventors' Advocate," vol. 5, p. 277; Patent No. 1,370.]

PIG IRON SOAKED IN WATER—MELTED IRON RUN INTO WATER, TO WHITEN AND PURIFY IT.

GREGORY, JAMES, and GREEN, WILLIAM.—1841. May 14. No. 8,959.

"Improvements in the manufacture of iron and steel." These consist in submitting the crude pig iron to the action of water. The iron, in the form of pigs, or broken small, is immersed in water, and allowed to remain exposed to its action "until there is no longer any change produced upon it; a period of from two to three weeks is generally sufficient for this purpose. The appearance of an oily looking scum on the surface of the water indicates that the water has produced its full effect upon the iron." Running water may be used, but standing water is preferred, as its scum indicates when the operation is completed. This process "causes the iron to become softer and tougher." If the iron is required to be of "close texture of that kind called brittle iron," it is to be heated to a bright red heat, and submitted to the action of cold water by sprinkling or immersion. If the iron be of impure quality it is fused in a "finery." Iron so treated is superior for casting and for conversion into wrought iron. The improved process for refining, which may be used alone, or in conjunction with that just described, is as follows: The iron is melted "in a reverberatory or other suitable furnace," and then poured, "while in its melted state, through a vessel, the bottom of which is perforated with holes about one-quarter inch in diameter, lined with clay. The fused metal is received in a vessel of cold water," of any size; by preference it should be so deep "that the drops of metal may be well cooled." Iron is considerably refined by this operation; it "possesses a close texture, and is of a white color," and is "much better adapted for conversion into steel than the iron manufactured in the ordinary method."

[Printed, 3d. See "London Journal" (Newton's), vol. 21 (conjoined series), p. 31; "Mechanics' Magazine," vol. 35, p. 413; and "Inventors' Advocate," vol. 5, p. 334 See Patents, Nos. 759, 4,151.]

BRIDGE CONSTRUCTION.

The principles and practice in modern iron bridge construction are thus mentioned in "Engineering": Little that is new in principle has been achieved during the last year. Wrought iron arches, where arches are employed at all, are certainly coming into increasing favor. The widest wrought iron arch yet constructed is that of the Pont d'Arcole, in Paris, 262 ft. in clear span. A somewhat later example was that of the bridge over the Thiess, at Szegedin, in Hungary, and Mr. Fowler was the first to adopt wrought iron arches in England, viz., in his fine railway bridge, of four 175 ft. spans, across the Thames, at Pimlico. Mr. Fowler has attempted, experimentally, with great success, to construct a large concrete arch, with a view to the application of the system in his practice. On the Continent concrete voussoirs are sometimes employed, and the attainment of a monolithic arched bridge, of considerable span, is not beyond the resisting powers of the material.

Engineers should examine fully into Mr. Sedley's proposed system of double cantilevers with an arched or trussed span placed between them. It secures a very considerable economy of material in long spans. Mr. Sedley not long since tendered for the construction of the great Moerdyk bridge,

which he proposed to complete in eleven spans of 400 ft. each, on an estimate of between £600,000 and £700,000.

It is desirable also to inquire if more than one tension member is necessary in trussed bridges carrying their load on the level of the upper booms. We last week illustrated a Norwegian bridge of triangular section, only one tension member being provided for the two booms in compression. So, too, the great (455 ft.) spans of the Saltash bridge have each but one compression member, and we may note that in his design for the Kentucky railway suspension bridge, of 1,224 ft. clear span, Mr. Roebling proposed to employ a single stiffening girder of timber beneath the roadway.

When rolled rings, requiring no riveting, are once produced upon a commercial scale, it is probable that engineers will introduce new forms of compression members in all trussed structures, the circular strut being far stiffer for a given weight of iron than the cruciform section obtained by riveting up ⊤ or angle iron.

There is a greater tendency towards pin jointing in trussed girders, as distinguished from the clumsy mode of riveting the parts together. Warren's girders have always been made with turned pin joints, as are the joints of all chain suspension bridges, and Mr. Hawkshaw has employed turned pins instead of rivets to a very considerable extent, as in his Charing Cross and Londonderry bridges. In America, Fink's, Bollman's, and the Murphy-Whipple iron bridges are all made with turned pins.

But, after all, there is less to be said of the structure than of the appearance of our bridges. When shall we have engineering science wedded to true architecture, as in the case of Mr. Page's fine bridges, and in those, worthy a superior age, constructed by Mr. Joseph Mitchell upon the line of the Highland Railway? The latter, taking their abutments and piers along with their girders, are the finest railway bridges ever constructed, except with arches. Too many, far too many, of our engineers take a pride in ugliness, and perpetrate it wilfully. The time will come when offended taste will cry out and demand the demolition of their ugly works, and we shall not be surprised if the time is soon. Bridge work should no longer be all calculation and contract, but be redeemed by the graces which refined minds are always so ready to lavish upon structures of far less publicity and importance.

THE "ROUND OAK" COAL AND IRON WORKS.

Mr. Samuel Griffiths, in the "Birmingham Daily Gazette."

The Earl of Dudley's iron works at Round Oak are situated on the high road between Dudley and Brierly Hill, and are, without doubt, the most complete in South Staffordshire, regularly turning out a quality of iron unrivalled by, if not superior to, the production of any works in the Black Country. We arrive at this great establishment by the West Midland division of the Great Western Railway, which runs parallel with one angle of the works. A canal connects it with the North-Western Railway, and 12 locomotive engines are employed to serve these works, thereby rendering assistance also over 40 miles of railway, which traverse his lordship's colleries. The works, together with the offices, etc., cover 30 acres of land, and they are capable of turning out from 500 to 550 tons of best finished iron per week. There are nine steam engines in the mills and forges, all working vertically or horizontally, and a very large steam hammer, with the last improvements, which is capable alike of dropping a 20-ton blow or cracking a nut without bursting the kernel. Here they have four large forge hammers or helves, and this is the only method adopted to form the puddled balls into blooms or slabs, as they may be required. Old fashioned shingling is the practice here; neither squeezers nor patent shingling of any kind is resorted to.

There are five rolling mills—one 16 in. plate mill, a 12 in. ditto, an 8 in. and 7 in. bar mill, with a good hoop mill; and the space allotted to the hoop mill and the fencing wire mill—indeed, all the mills in these works—is admirable for its extent and convenience. The speeds are higher than anything in South Staffordshire, and the machinery, by its quiet and steady motion, forcibly reminds one of the regularity of clock-work. We have no hesitation in saying that the construction and perfection of the gear which drives all the mills and forges supersedes anything we have seen in this or any other country. The wheels, when in full work, make very little noise; the driving wheels are large, and as the engines run fast, the nut on the fly shaft of necessity is very rapid, but the sound resembles the gentle murmur of the crabwood gearing of a flour mill rather than the unremitting contact of metal with metal in

their constant revolutions. We hear no banging sounds like a sledge hammer on the cog of a wheel, which are generally heard in the iron works of the Black Country. We were much struck with the truth of all the driving wheels; indeed, the general lines of the work reminded us of a parallel, always square and rightly placed. We could not help observing the scientific distribution of metal in the numerous wheels and shafts. Even those unwieldy blocks of metal called cam-rings were shaped with a view to a scientific distribution of the iron, and the engineer, while exercising economy in this respect, had not forgotten the ornate. There are 53 puddling furnaces, nine ball furnaces and two heating furnaces. The fettling used is ground bull-dog only. Neither pottery mine nor hematite ore is permitted in the works.

The bull-dog is calcined exclusively from the taps of the puddling furnaces on the spot. The puddling furnaces are fixed at equi-distance from the hammers, and as the interior area is completely laid with square plates, the roofing being sustained by a very high wall plating on columns all round, the works present a clean and comfortable aspect, and must be comparatively cool in summer time, which is a great desideratum. A railway serves the coal and removes the ashes from the back, while a second railway deposits the pig-iron and ground bull-dog on the standings at the front of the furnaces. The kilns for calcining bull-dog are fixed at equi-distance between both works, and a railway takes the taps from the works to the kilns, returning loaded with the ground fettling for the puddling furnaces, which struck the writer as a very perfect and economic arrangement for this otherwise dirty and expensive process. The last erections here are the new forges, situated a few hundred yards from the old mills, containing 28 puddling furnaces, fixed round the works in the shape of a horse-shoe, being ministered to by two large forge hammers, which are driven by two vertical engines 55-horse power each, each engine driving a hammer, forge rolls, &c., *per se*, so that the motive power of the one is disconnected with, and independent of, the other; the engines, driving wheels, rolls, &c., being fixed parallel with the heels of the horse-shoe figure of the forges, a space is left between the driving wheels, and the engines being fixed underground, but everything as firm as a solid rock. The puddling furnaces are served with coal, metal, &c., by rail, back and front, as described above, and the puddled bars, billets, &c., are removed by rail, with locomotives, into the mills, which are at some little distance, for consumption.

It must be observed that the whole of the pig-iron or plate-iron consumed is made from the Earl of Dudley's mines, raised on the estate, and smelted at his own blast furnaces. Nothing is used but his lordship's ten-yard coal, which is doubtless the best in the world for the manufacture of iron. No foreign pigs of any kind are permitted in the works, hence the famous quality of the iron produced. These great works are justly famed for the manufacture of large rounds and squares. Rounds are rolled here as high as six and a half inches diameter down to seven-wire gauge; and the higher sizes of rounds are in general request at the machine shops of the kingdom for piston rods, owing to the compactness and superior quality of the iron rolled here. Boiler plates are made with facility, of large size, up to 18 cwt.; angle bars and T-iron of great length are made, from 6 in. by 6 in. to $\frac{3}{4}$ in. by $\frac{3}{4}$ in. flats of all thicknesses, from 12 in. down to $\frac{1}{2}$ in. wide; an unequal size of angle iron, from 8 in. by $2\frac{1}{2}$ in. down to 2 in. by 1 in.; likewise channel iron, from $3\frac{1}{4}$ in. to $\frac{3}{4}$ in.; glan iron, ovals, round-edged flats, core bar iron, bevel iron; Z-iron, or, in other words, double-angle iron; square-edged and feather-edged iron, boat-guard iron, shutter iron, great bar iron, with various other specialities too numerous to mention. Here likewise the famous U-iron is produced, which up to this time has not been rolled at any other works in England. Rails of a very superior quality are likewise manufactured here, for the rolling of which the works offer great facilities. A layer of steel is welded on the top of the rail, the web or foot being made of his lordship's best fibrous iron, which is said to give greater strength and durability to the rail than the steel rail made in other districts.

The Earl of Dudley's iron stands quite at the top of the Staffordshire makes, and possesses all those peculiar qualities which have rendered Staffordshire iron so famous throughout the world in a more eminent degree than any other maker. This mainly arises from two causes—first, the splendid ten-yard coal, so abundant in his lordship's estates; and, secondly, the superiority of the earl's argillaceous iron-stones found west of Dudley. The iron produced here is consumed by shovel and spade makers (in plat-

ing bars), for horse-shoes, rivet-iron, cotton rollers, gun barrels, bayonet iron, saddlers' iron-mongery, for wire-drawing purposes, locomotive engines, and agricultural machinists' purposes. Its tension while hot in punching is marvellous. It is likewise used for all bright work, easily polishing without specks, and for other specialities, which renders its adoption desirable where it can be obtained.

The Earl of Dudley's finished iron is largely consumed at the great engine shops on the banks of the Neva, in Russia, and is sent to Canton, Foo-chow-foo, and Pekin, in China; to Hokudadi and Yokohoma, in Japan; Cabul and Candahar, in Affghanistan; and even the almost unexplored regions of Thibet are supplied, via Cashmere, with some particular kinds of iron from these famous works; and pig-iron with his lordship's brand was found in Theodore's cannon foundry in Abyssinia, which must have been carried for some hundreds of miles on the backs of the attenuated mules of that country. The superiority of this marvellous iron is owing, no doubt, to three or four circumstances. In the first place, all other makers buy different mixtures of pig-iron. The Earl of Dudley makes at his blast furnace establishment the best iron that can be made out of the materials raised in his own estates, and consumes these pigs, and no others, at the Round Oak Works.

The Round Oak Works were founded by the late Mr. Richard Smith, who for thirty years was faithfully and successfully engaged in developing his lordship's coal and mineral empire. The tact, talent, and business abilities of the late lamented Mr. Smith were well known and appreciated in the iron trade. Mr. Frederick Smith, the present manager, is a gentleman and a scholar, a Fellow of St. John's, Oxford, but obtained immense practical knowledge under the guidance of his late father; and as he inherits the business qualities of his father, the efficiency of the management continues unabated. Probably a greater willingness is evinced to adopt all modern improvements and adapt these great manufacturing operations to the requirements of the day, keeping abreast in all departments with the rapid progress of the iron age in which we live.

NAVAL ENGINEERING.—At the late meeting of the Institution of Naval Architects, many important papers were read, abstracts of which will appear in these pages.

HYDROGEN AS AN ILLUMINATING GAS.

From the "Mechanics' Magazine."

In every process, chemical or mechanical, a certain amount of loss or waste of either material or power must take place. The results obtained by a chemical process never coincide exactly with the theoretical formula, nor, mechanically, can the work done ever equal the power applied. An ignorance, or, what is worse, a culpable neglect of these fundamental principles, has led scientific fanatics to spend their time, money, and ultimately their lives, in a fruitless search after the impossible. The loss accruing to ordinary gas, from the very commencement of its manufacture, to the moment that it flows from the burners, as a source of illumination, is occasioned by both chemical and mechanical unavoidable imperfections. The latter is caused by leakage, owing chiefly to defective joints, unsound pipes and the carelessness of those who are concerned in its manipulation and distribution. The former is due to chemical action solely, and could scarcely be prevented, which is not the case with the other sources of loss. About fourteen per cent may be taken as the average loss incurred in the manufacture and burning of ordinary gas, or that which represents the actual discrepancy between the theoretical and practical results. The composition of ordinary gas consists mainly of carbureted hydrogen gases; and as hydrogen itself possesses no power whatever of illumination or brilliancy, it is not, at first sight, quite obvious what advantage results from its presence. Anyone who has dabbled in elementary chemistry is aware that hydrogen gas, when tolerably pure, burns with a pale blue flame, emitting little or no light, but endowed with a very high temperature. At the same time, by causing its high temperature to act upon other bodies, such as platinum and lime, it develops a flame of great beauty and brilliancy. To a similar cause is due the illuminating properties of ordinary gas. The action of the high temperature of the burning hydrogen upon infinitesimal particles of carbon renders them incandescent, and imparts to the gas its powers of illumination. Hydrogen, therefore, destitute of brilliancy when pure, becomes possessed of that property when in mechanical combination with carbon—in other words, when it is carbureted. If it were possible to bestow upon hydrogen illuminating properties without carbureting it, as in the ordinary manu-

facture, the whole process would be rendered much simpler and more economical.

It has been asserted that it would be found a great advantage to employ a much larger proportion of hydrogen in the ordinary gas than what at present prevails; in fact, to constitute it rather a hydrogen gas than that of which it is now composed. A very large proportion of hydrogen is lost in the manufacturing process, which might be easily preserved and utilized, resulting in the production of a gas of a superior quality. The same may be stated with respect to other volatile and illuminating ingredients, including the paraffin and benzine, which, for the most part, are left in the bye products. Were hydrogen more carefully sought for and preserved in the manufacture of gas, the volume would be considerably increased, in addition to a greater purity being imparted to the product. It is notorious that the ordinary gas, in many of the smaller towns, is so impure, and possessed of so small an il uminating power, that many persons refuse to have it laid on to their premises. A gas composed mainly of hydrogen would be free from most of the noxious and disagreeable properties unquestionably possessed by our present great source of public illumination, but until it can be demonstrated that a better gas can be supplied at the same rate, we shall, as usual in such matters, stick to the old plan of manufacture.

IMPROVEMENT IN PUDDLING.

FINE ORE STIRRED IN WITH THE CHARGE.

The remarkable results of the Ellerhausen process—mixing 30 to 33⅓ per cent of fine ore with pig iron, previous to its treatment in the puddling furnace, has led to a number of experiments in a similar direction. One of the most important of these experiments was recently made at the works of Messrs. Henry Burden & Sons, Troy, and consisted in melting the pig iron in a puddling furnace fettled with about half the usual quantity of lump ore, scattering over the iron and stirring into it 30 per cent of fine ore, lowering the heat slightly to give the iron and ore time for reaction, and then raising the heat and balling the charge in the usual manner, but with a saving of some 30 per cent in time and an improvement in quality of product. This treatment was clearly pointed out, in kind, but not in degree, by David Mushet, 34 years ago.* The results given below were furnished by Messrs. Burden for the public benefit, and were ascertained with great care and accuracy.

* See Van Nostrand's Magazine, No. 4, page 361.

Record of Experiment at Nos. 10 *and* 12 *Single Puddling Furnaces, "Burden Iron Works," week ending* 20*th Feb.*, 1869, *charging* 448 *lbs. of Pig Iron to each heat, and using* 30 *per cent. Fine Ore.*

No. 10 FURNACE.

MATERIAL CHARGED.

DATE. 1869.	Turn.	Pig iron charged.	Coal.	Fettling ore.	Fine ore.	Iron made.	Heats.
Feb. 15...	Night.	3,584	6,000	3,425	1,072	3,620	8
16...	Day.	3,584	6,800	2,000	1,072	3,688	8
	Night.	3,584	.....	.....	1,072	3,756	8
17...	Day.	3,584	6,400	1,500	1,072	3,648	8
	Night.	3,584	.....	.....	1,072	3,500	8
18...	Day.	3,584	7,200	1,000	1,072	3,592	8
	Night.	3,584	.....	.....	1,072	3,610	8
19...	Day.	3,584	6,800	2,000	1,072	3,882	8
	Night.	3,584	.....	.....	1,072	3,935	8
Sat. 20 ..	Day.	1,792	1,600	.....	536	1,852	4
		34,048	34,800	9,925	10,184	35,053	76

No. 12 FURNACE.

MATERIAL CHARGED.

DATE. 1869.	Turn.	Pig iron charged.	Coal.	Fettling ore.	Fine ore.	Iron made.	Heats.
Feb. 15...	Night	3,584	6,200	3,220	1,072	3,833	8
16...	Day.	3,581	6,800	2,300	1,072	3,820	8
	Night.	3,584	.....	.....	1,072	3,917	8
17...	Day.	3,584	6,800	2,000	1,072	3,610	8
	Night.	3,584	.....	.....	1,072	3,698	8
18...	Day.	3,584	6,800	2,000	1,072	3,736	8
	Night.	3,581	.....	.....	1,072	3,762	8
19...	Day.	3,584	7,200	2,000	1,072	3,682	8
	Night.	3,584	.....	.....	1,072	3,642	8
Sat. 20...	Day.	2,240	1,600	.....	670	2,300	5
		34,496	35,400	11,720	10,318	36,003	77

SUMMARY OF RESULTS.

Old System Puddling.	*New System Puddling.*
Coal consumed per ton of puddled bars .....2,698 lbs.	Coal consumed per ton of puddled bars .....2,213 lbs.
Fettling ore consumed per ton of puddled bars .....1,374.	Fettling ore consumed per ton of puddled bars.....092 lbs.
Average turn six heats, 2,667 lbs.	Fine ore consumed per ton of puddled bars.....646 lbs.
No waste.	Av. turn eight heats, 3,552 lbs.

Saving by new system in coal per ton of puddled bars over old system..... 485 lbs.

Increase in consumption of ore per ton of puddled bars over old system..... 46 lbs.

Increase in product of puddling furnace over old system..... 34 per cent.

Gain in yield of both furnaces over old system during the week..... 2,512 lbs.

LIGHT RAILWAYS.—Mr. Zerah Colburn is preparing a very comprehensive paper on this subject, to be read before the Institution of Civil Engineers.

IRON AND STEEL NOTES.

STRENGTH OF STEEL VARIOUSLY CARBURIZED.—The following tables are from a list of experiments made by Mr. Thomas E. Vickers, of Sheffield:

Softest, or least carbonized steel containing .33 per cent carbon, marked No. 2. The hardest, or most highly carbonized, containing 1.25 per cent carbon, No. 20; the intermediate numbers representing intermediate degrees of carbonization.

TENSILE STRENGTH.

Description of steel.	Proportion of carbon. (Approxi.)	Breaking strain per square in.	Elongation.	Specific gravity.
No.	Per ct.	Tons.	Inches.	
2	0.33	34	1.37	7.871
4	0.43	34.0	1.37	7.867
5	0.48	37.5	1.25	7.855
6	0.53	42.5	1.12	7.855
7	0.58	41.5	0.81	7.852
8	0 63	45.0	1.00	7.848
10	0.74	45.5	0.69	7.847
12	0.84	55.0	1.12	7.840
15	1.00	60.0	1.00	7.836
20	1.25	69.0	0.63	7.823

Tensile strength is increased by the addition of carbon until the steel contains 1.25 per cent, when it sustains about 69 tons per square inch; beyond this degree of carbonization the steel becomes weaker, until it reaches the form of cast iron.

Transverse Strength of Axles.—Axles turned to 3.94 inches diameter at center, 3.25 at the ends, placed on bearings three feet apart; ram weighed 1,547 lbs.; dropped on center of axle from height of one foot, increasing up to 36 feet fall.

Material of axle.	Proportion of carbon. (Approximate.)	Total number blows.	Height of fall in last blow.	No. of blows sustained from 36 feet high.	Sum of deflection.
	Per ct.		Ft.		Inch.
Steel No. 2	0.33	17	36	4	58.81
Steel No. 4	0.43	18	36	5	56.00
Steel No. 5	0.48	18	36	5	53.56
Steel No. 6	0.53	15	36	2	35.06
Steel No. 7	0.58	16	36	3	38.81
Steel No. 8	0.63	18	36	5	46.00
Steel No. 10	0.74	16	36	3	40.31
Steel No. 12	0.84	10	20	..	8.56
Steel No. 15	1.00	8	12¼	..	4.31
Steel No. 20	1.25	10	20	..	6.94
Best wrought iron	.....	13*	36	..	31.19
Scrap iron	.....	5	5	..	2.00
Scrap iron	.....	5†	5	..	3.69

CONSTRUCTION OF BLAST FURNACES.—An interesting and instructive experiment bearing upon the construction of blast furnaces, has recently been made at the "Consett Iron Works," at Durham, England. The Consett Iron Company smelt each year about 200,000 tons of ore in four blast furnaces. At present the waste gases are only taken from one furnace, on the bell and hopper system, but one of the furnaces is being altered so that the waste gases can be taken off on a modification of the side flue system, a little novel in character. The blast is heated just now to 1,000 degrees by a couple of ⌂ cast-iron pipe stoves. These are to be removed, and four stoves on Whitwell's principle substituted, from which the best results are anticipated. Mr. Radcliffe, the superintendent, believes that the extraordinary results obtained from the high and large furnaces now popular in the Cleveland District are due not so much to the dimensions of the furnace as to the excessively high temperature of blast with which they are worked, and is inclined to the opinion that the proper capacity of furnaces has been overstepped, and cites the following interesting fact in support of his theory. Some time since it was decided that a new furnace should be erected at Consett, with a height of seventy feet.—It was built and worked for some time; but the yield per ton of coke and the quality of iron were both found to be inferior to the yield and quality from the other and smaller furnaces. The furnace worked on Cleveland and hematite ore with a very good and clean coke quite capable of carrying the burden. It was then determined to cut the furnace down to a height of fifty-five feet, and the result was eminently satisfactory; the yield and quality were greatly improved, and the furnace is now one of the very best in the district. The blast is supplied by two high-pressure engines of an old type, with six feet six inches blowing cylinder, nine feet stroke, and a supplementary engine, which also drives a pair of plate rolls. The waste gases are used to raise steam in a magnificent set of new boilers, six in number, each 70 feet long, egg-shaped, with a diameter of 3 feet 10 inches. They are set in a very peculiar way. Cast-iron columns are erected on the brick-work in which they are set, and on these are supported five cast iron girders running across the tier of boilers.

From these girders depend sling stays, which are secured to double angle iron semi-circular rings riveted to the upper side of the boilers. A straight flue, 70 feet long, runs the whole length of the boiler below, right to the stack. The stack in connection with these boilers is 250 feet high, and 24 feet diameter inside at the base.—*Bulletin Am. I. & S. Ass'n.*

PHOSPHORUS IN CAST-IRON.—While the question of phosphorus and its effects on iron is being discussed, the following method of examination employed by a French metallurgist, M. V. Tantin, deserves notice.

M. Tantin says: "It is well known that very small quantities of phosphorus produce no sensible alteration in the quality of cast iron, whereas if the proportion exceeds a few thousandth parts the iron is robbed of its most essential qualities. It is very important, therefore, to ascertain the exact amount of phosphorus present. Nearly all the methods in use for this purpose consist in treating the iron by means of oxidizing agents, so as to cause the phosphorus to pass into the condition of phosphoric acid, which is precipitated in the state of a magnesian compound.—Several causes of error exist in this treatment. for (1.) a part af the phosphorus escapes the action of the agents, and disengages itself in the form of an hydrogenous compound. (2.) It is necessary to act upon very diluted solutions to prevent the ammoniacal-magnesian phosphate mixing with the oxide of iron, in which case it is difficult to collect the small amount of phosphate deposited in the sides of the vessel in which the precipitate is made. (3.) The arsenic which may be contained in the iron enters into the magnesian precipitate in the form of arseniate as insolubie as the phosphate.

* Cracks began to show at 10 lb. blow, with 20 feet height of fall, and increased with each such subsequent blow.

† Two large cracks opened at five pound blow, and considered as broken.

"In order to avoid these objections, I tried to attain my object by a directly opposite road, that is to say, in disengaging the phosphorus in the form of an hydrogenous compound, but then arose the question whether the whole of the phosphorus passed into the form of a gaseous product. This was, however, proved by the fact that no trace of phosphorus was ever to be found in the residuum after the iron had been completely acted upon by hydrochloric acid. This result ought to cause no surprise, considering the very energetic affinity which phosphorus has for hydrogen. The phosphureted hydrogen produced by the action of hydrochloric acid on iron is almost always accompanied by sulphureted, arseniated, and carbonated hydrogen. In order to effect the separation of these gases, they may be made to pass first through a Wolf's bottle containing a solution of potash, which absorbs the sulphureted hydrogen; then through a solution of nitrate of silver, which transforms the arseniated hydrogen into arsenite of silver soluble in the liquid becomes slightly acid, while phosphureted hydrogen precipitates the argentine solution and forms insoluble phosphorus.—The phosphorus being thus absolutely separated from the sulphur and the arsenic, its amount is ascertained with the greatest ease; the phosphure of silver is treated with nitro-muriatic acid, and thus transformed into chlorure of silver and phosphoric acid, which is precipitated in the form of ammoniacal-magnesian phosphate. This precipitate, when calcined, gives the proportion of the phosphorus to the iron.

"In order to obtain the whole of the phosphorus the following precautions must be observed: Let the iron be attacked gradually, otherwise a portion of the phosphureted hydrogen may traverse the solution of nitrate of silver without being absorbed. And when the action on the iron is finished, pass through the apparatus a stream of hydrogen which has previously been washed in acetate of lead.

"The solution of potash contains all the sulphur which was present in the iron treated, and in order to ascertain the quantity of that substance the olution must be treated with acetate of lead; the precipitate produced is at first a mixture of oxide and sulphite of lead, but the oxide is soon redissolved and the sulphite still remains. The precipitate must be collected in a filter, washed with distilled water, and completely dried before being weighed."—*The Engineer.*

THE SIEMENS-MARTIN PROCESS.—The "Mining Journal" says that Mr. Bernard Samuelson, M. P., has erected extensive works at Newport and South Stockton, for the manufacture, on a very large scale, of rails, angles, plates and sheets, by this process. Richardson and Johnson's process of purification, will be used in the preliminary processes, and Siemens' furnaces for heating, &c., are to be employed throughout.

EXTENT OF THE BESSEMER MANUFACTURE ON THE CONTINENT.—There are now in use in Europe, Italy and Russia excepted, 128 Bessemer converters, these having a total capacity of 555 tons. Krupp is the largest owner of Bessemer converters, there being thirteen at the Essen works, some of them having a capacity of seven tons. In France 20,000 tons of Bessemer steel were made in 1867, and 35,000 tons in 1868.

WATER BOSHES FOR CUPALAS.—In the "Mechanic's Magazine" of February 12. 1869, this construction, as patented by Mr. John Thomas, of Newcastle-on-Tyne, is fully illustrated and described. The object is to prevent the excessive wear of bricks. The water boshes are covered on the inside with spikes, like a founder's loam plate, by which the refractory lining is held in place.

NEW METHOD OF PILING LARGE ARMOR PLATES.—An experiment in rolling large armor plates was recently made at the works of Sir John Brown & Co. The plate manufactured and finished is 12 ft. 8 in. long, 8 ft. 6 in. wide, and 5 in. thick. The difficulty experienced in producing large plates has hitherto been in heating sufficient wide piles in the furnace, and in thoroughly driving out the slag and cinder, which would become incorporated in the plate. By the process of Mr. Ellis, the managing director of the company, the piles are built up comparatively narrow, and are passed through the rolls until the length of the mass becomes equal to the finished breadth of the plate. The pile is then turned and rolled out in the direction of its breadth, until the required length and thickness is attained. The pile from which the plate was constructed was built up of five slabs, each 7 ft. by 6 ft., and 3¼ in. thick, weighing 14 tons, and was heated for sixteen hours previous to rolling, which operation occupied three-quarters of an hour from the time when the pile was withdrawn from the furnace. The successful issue of this experiment promises a great advance in the manufacture of large armor plates; and the difficulty of dealing with piles being avoided, plates 8 ft. wide, and not only 12 ft., but 20 ft. or 30 ft. long, can be produced by the method of Mr. Ellis.—*Engineering.*

CONTINENTAL COMPETITION WITH ENGLAND.—Belgium and France often obtain considerable orders from the Russian and Austrian railways. The plan adopted in Belgium is to form a committee of ironmasters, who appoint one of their number to tender for any large contracts that may be offered. He proceeds to the spot, and works for the interest of all the makers of rails in Belgium; the ironmasters decide upon the terms which he may offer, and the orders are divided among them pro rata of their means of production. Payment being very often made by bills or guarantees, which individual firms could not accept without danger, a financial association supports the operations of the committee; by these means the risk is divided amongst a large number of individuals, and when losses are made they are less heavy, from being divided. Our authority also has the following: The English railmakers formerly supplied the greater part of the steel rails required for the American railways; now the French houses seem to threaten formidable competition. MM. Potin-Gaudet et Cie. have, it is said, recently supplied 5,100 tons of steel rails to the New York Central Railway Company, and considerable quantities to other companies.—*Journal des Travaux Publics.*

BLAST FURNACE SLAG FOR BUILDING AND PAVING.—The following method is now adopted in several iron works in Belgium: The slag is allowed to run direct from the furnace into pits about eight or nine feet in diameter at the top, with sides sloping inwards towards the center, where they are about three feet deep. The mass is left for eight or nine days to cool, when a hard, compact, crystalline stone is obtained, which is quarried and used for building purposes, but chiefly for paving-stones. They appear to wear exceedingly well, being quite equal to the grits and sandstones already so much used.

EXPANSION OF IRON DURING COOLING.—It is stated in the "Scientific Review" that Mr. Gore, of Birmingham, whilst making some experiments on heating a strained iron wire to redness by means of a current of voltaic electricity, has observed that on disconnecting the battery, and allowing the wire to cool, during the process of cooling the wire suddenly elongated, and then gradually shortened until it became quite cold. No explanation of the action has, so far as we are aware, been advanced.

ORDNANCE AND NAVAL NOTES.

KRUPP'S NEW ELEVEN-INCH GUNS FOR RUSSIA.—About five years ago, when the Russian artillery made use of muzzle-loading rifled cannon, the Russian government had ordered of M. Krupp a cast-steel gun on that system, rifled 11-inch bore, English measure. Since then, numerous experiments having been considered to prove the superiority of breech-loading guns throwing projectiles larger than the bore, the Russian artillery has decided on adopting these guns exclusively. At the time of this decision the 11-inch was in a forward state of manufacture as a muzzle-loader, and when its conversion was contemplated, there was reason to fear that the walls of the gun would be too thin for the slot for the breech-piece; but further experiments on the resistance of breeches of different thicknesses having demonstrated the possibility, the alteration to a breech-loader on Krupp's principle was made. This gun has been subjected to a prolonged trial of 400 rounds, the number fixed by the Russian authorities. The details of the gun are:—Total length of bore, 160.2 English inches; length of rifling, 113 in.; number of grooves, 36; weight of gun, 25 tons, 11 cwt. 3q. 3 lb. The weight of the projectile is 496 lb.; the weight of the charge, 82¼ lb. of Russian prismatic powder. The initial velocity communicated by this charge to this projectile was 1,308 ft. The gun stood the 400 rounds with this charge, and remained in a serviceable condition. The above quantities, as well as those which follow, are all in English measure, the equivalents having been reduced from the Prussian denominations.

The breech-piece was Krupp's single round wedge. Two were furnished for the experiments, one having a Rodman knife apparatus for measuring the pressure of the gas in the chamber, and which was only used for that purpose; the other an ordinary breech-piece intended for the endurance trial. This breech-piece, in this experimental practice, worked through-out with the greatest ease, and all escape of gas was perfectly prevented by one Broadwell ring, which sufficed for the whole number of rounds. The explosion of the charge took place in the direction of the axis of the bore, ignition having been effected by a vent through the breech-piece. The gun was sponged out after every 30 rounds, but care being always taken to lubricate the lead coatings of the projectiles there was not the slightest appearance of lending in the grooves. The gun was sponged with soapy water, which effectively removed the slightest fouling. The guttering formed at the seat of the projectile during the firing by the passage of the gas did not exceed three millimetres in depth at the finish of the trial, and all did not seemingly attain this depth. These channels are larger than those observed after 725 rounds in the Krupp breech-loading 9-inch gun, and this circumstance is attributed to the fact that the 11-inch gun had an ordinary chamber concentric with the bore; whereas all the guns of the new construction—such as the 9-inch gun referred to—have eccentric chambers. The 11-inch gun, having been a muzzle-loader, has not the necessary length of bore for a breech-loader, and the new breech-loading guns of this calibre about to be supplied from Krupp's works will have the bore longer by 2½ calibres, so that the initial velocity communicated to the 496-pounder shot by a charge of 82¼ lb. of prismatic powder will be increased to about 1,360 ft. per second. The gun was discharged, as we have said, by a vent through the wedge; but there was another vent on the top of the gun, which was closed by a steel screw, and was not used. The objects of the experiments were to ascertain the charge required to give a shot 550 lb. Russian (496 lb. English) an initial velocity of at least 1,300 ft.; to demonstrate by a trial of endurance that, with the charge thus arrived at, a Krupp 11-inch breech-loader will stand a greater number of rounds than is required to render it fit for active military service.

With respect to the powder, experiments in Russia and at Essen had shown that the prismatic powder introduced into Russia some years since was very well adapted for attaining a high initial velocity without an excessive strain on the gun, and the Russian government, therefore, sent to Krupp's factory a quantity of this power, manufactured in 1865 at Ochta, for these trials. The factory had also a stock of prismatic powder made by Ritter, of Hamm, in Rhenish Prussia, according to the Russian formula. The cartridge bags were of single cotton stuff, the cartridge forming a regular hexagon, with tiers of 37 prisms; the greatest diameter of the hexagon being 9.65 in., the smallest 8.80 in.; the length of the cartridge without the choke, 27 in. The shot were of solid cast iron, with lead coating. The gun was mounted on a proving carriage with cast-iron sides, which afforded no convenience for loading; the recoil was on an inclined plane, so that the gun, after each round, ran back to nearly its original position. It stood in a roofed place, and the firing was into an earth butt at a distance of about 62½ ft., also roofed over. The initial velocity was taken with Captain Le Boulange's chronograph; the first wire target stood at 18 ft. from the muzzle; the second was 32.9 feet from the first. The target wires were fastened separately to iron frames; their thickness three-eighths of an inch in the front, and a quarter of an inch on the second target; the insulated communicating wires were perfectly protected from the gas when the gun was fired. The average pressure of the gas of 3,209 atmospheres is stated to be far from straining the gun up to its limit of elasticity. Ritter's powder, according to the details of the experiments, appears to try the gun less than the Russian powder. The piece was served by eight men, two of whom had to fetch the cartridges from a magazine 150 metres away. For the sake of the durability of the earth butt the shot were dug out after every 60 or 70 rounds. Between every two days consecutive firing gutta-percha impressions were taken and the chamber measured. The gutterings have not, even after 400 rounds, assumed a character in any way serious to the durability of the gun. The regular breech-piece did duty in the gun during 307 rounds, with a charge of 91 Russian lbs. (82¼ lbs. English).

Putting together, for comparison, the results of the trials with Krupp's 9-in. 12-ton gun, with hoops, tried in Russia, his 11-inch gun (26 tons), with hoops (trial at Essen), and our English 12-inch muzzle-loader (trials in England), we have the *vis viva* of the shot in metre tons as follows:

Gun.	Caliber.	Charge.	Shot.	Initial Velocity.	Vis viva. Meter Tons.	Vis viva per Centimeter. of Circumference. Meter Tons.
	in.	lb.	lb.	ft.		
Krupp's b.l. 15 tons.	9	46	275	1,340	1060·5	15
Krupp's b.l 26 tons.	11	82½	475	1,353	1975·0	23
English m.l. 21 tons.	12	79	600	1,180	1796·7	19

According to the above formula, Krupp's 26-ton 11-inch breech-loader is a more powerful gun than our 12-inch 24-ton muzzle-loader. The new guns, now making under the Russian contract, will be of rather larger measurements than the converted gun used in the experiments above described. Their details will be: Weight, including breech-piece, 25

tons 11 cwt. 3 qr. 3 lb.; no preponderance at the breech; length over all, 18 ft. 4 in.; rifling—36 grooves, 0.135 in. deep, 0.76 to 0.64 in. wide; width of lands, at chamber, 0.17 in.; of grooves, 0.79 in.; at muzzle, 0.17 in. and 0.32 in.; diameter of bore over the lands, 11 in., over the grooves, 11.40 in.; weight of steel shell loaded, 496 lb.; charge for gun, 82 lb.; initial velocity of projectile, 1,360 ft.—*London Standard.*

STEAM LAUNCHES.—One of the most important parts of the equipment of a ship of war is undoubtedly her boats and their capabilities. In this respect the ships of the English navy, a few years since, were far behind those of France or Russia; but at the present time they are much more efficiently provided than the ships of any other nation. For some time after steam-power was applied for the propulsion of boats attached to ships of the French and Russian navies, our own authorities stood by oars and sails, and when they did follow on the new track it was only done at first in a compromising and bungling kind of way. In their application of steam-power to boats our friends aimed at rendering the boat a kind of miniature despatch tender to the ship, possessing as much speed as could be given by the engine and boiler carrying power of her tonnage, without the usual heavy gun at the bow or stern, and with no great capacity for stowage beyond fuel, but with good towing powers, so that she could take a string of heavily-armed boats into or out of any position that might be desired on a coast at a moderate speed. Our first efforts in the same direction was to place twin-screw engines and boilers in the heavy built steam-launches already attached to our ships, retaining them at the same time in all their original form as gun-carrying boats, with armed crews and stores of shot, shell, masts, sails, oars, water, and provisions, &c.; the clumsy bluff-bowed monsters being, when thus loaded, scarcely able to hold their way against a moderate wind or tide in a river way, and useless altogether for towing purposes.

The fitting out of two surveying-sloops for service in the Chinese and Japanese seas led to the introduction of quite a different class of steamboat into our navy, a type of boat which more nearly approached that adopted in the French and Russian navies in its general principles as simply a despatch and towing-boat, but excelling them greatly in having superior speeds combined with the life-boat principle in the boat's construction, the latter arrangement rendering them unsinkable when filled with water to the gunwale's edge when carrying engine and boiler and a double crew on board. Quite recently also it has been proved that the engines of these boats can be driven noiselessly, a most important desideratum when they may be engaged on reconnoitring or cutting out expeditions; and orders issued from the Admiralty direct that all such boats in future supplied to her Majesty's ships are to be fitted with the engines working on the noiseless principle. The builder to the Admiralty of these steam life-boat launches and pinnaces, Mr. John Samuel White, of East Cowes, Isle of Wight, has sent in to Portsmouth Dockyard during the past week four pinnaces, Nos. 8, 9, 10 and 13, under his contract with the Admiralty, which have since been put through their trials by the officials of the yard, and very satisfactory and successful results obtained. After passing through the water-pressure test, they were finally tried over the measured mile. Nos. 8, 9 and 10 are boats of about 37 ft. between perpendiculars, and are driven by single screw engines of six-horse power nominal. No. 8 was tried at a draught of water of 3 ft. 1¼ in. aft, and 2 ft. 4¼ in. forward. Her four-bladed common screw had a diameter of 2 ft. 9¼ in., a pitch of 4 ft., a length of 6¾ in., and an immersion of the upper edge of 1 in. The mean revolutions of the engines were 249.33, and the boat's mean speed 7.986 knots per hour. No. 9 was tried at the same draught of water as No. 8. Her four-bladed common screw had a diameter of 2 ft., a pitch of 4 ft., a length of 6⅞ in., and an immersion of the upper edge of 2¾ in. The mean revolutions of the engines were 244.63, and the boat's mean speed was 7.988 knots per hour. No. 13 was tried at a draught of water of 3 ft. aft and 2 ft. 5¼ in. forward. Her four-bladed common screw had a diameter of 2 ft. 5¼ in., a pitch of 3 ft. 4 in., a length of 4⅞ in., and an immersion of the upper edge of 3¾ in. The mean revolutions of the engines were 282.66, and the boat's mean speed 7.288 knots per hour. No. 10 was tried at a draught of water of 3 ft. aft and 2 ft. 8 in. forward. Her four-bladed common screw had a diameter of 2 ft. 9¼ in., a pitch of 4 ft. 2 in., a length of 6¾ in., and an immersion of the upper edge of 1⅝ in. The mean revolutions of the engines was 249.5, and the boat's mean speed 8.040 knots per hour. It was boisterous weather when all the boats were tried over the measured mile. All four of the boats were very handsome and buoyant in their appearance when under full steam pressure in running over the measured mile.—*Army and Navy Gazette.*

THE VAVASSEUR GUN.—A steel 7-in. muzzle-loading gun, designed and built by Mr. J. Vavasseur, of the London Ordnance Works, Southwark, was recently submitted to a private trial, and, so far as could be judged by the eight rounds fired from it, with highly satisfactory results. The gun is made entirely of Firth's steel, the material from which the A tubes of the Woolwich heavy guns are formed.

The inner tube of the Vavasseur gun is similar to that of a service gun of the same caliber, and is covered for its whole length by an outer tube shrunk over the inner. This ring is in two lengths, the first reaching as far as the chamber, the second protecting the A tube from the chamber to the muzzle. Over the second tier is shrunk a series of steel hoops, which extend towards the muzzle of the gun. The trunnions are of wrought-iron, forged upon a wrought-iron band, which is shrunk over the gun, and the breech is closed by a steel cascable screwed into the end of the second or B tube, which forms the rear of the piece. The entire length is 123 in.; the length of bore is 111 in.; the external diameter at the muzzle is 12 in.; the diameter at the breech is 24.4 in.; the total weight, 5 tons 1 cwt.; the trunnions are so placed as to give a preponderance of 5½ cwt. The rifling has an uniform twist of 1 in 35 calibers, and consists of three ribs, with a flat table one inch wide, and raised from the bore about two-tenths of an inch.

This gun is mounted on a steel carriage weighing 22 cwt., the slides being 12 ft long, and 32 cwt. in weight, making a total of 54 cwt. The recoil is absorbed by a coned disc working within an iron drum, the rotation of which is regulated by an adjustable brake strap, tightened by a screw provided with an index divided into tenths. The disc, which is of iron faced with wood, is placed at the forward end of the slides, and is mounted upon a square-threaded screw shaft, with a pitch of 30 in., and which traverses the whole length midway between the slides. One end of the screw shaft carries the disc, which is 14 in. in diameter and 2 in. wide, and which fits within the drum before mentioned. The under side of the carriage carries beneath it a nut working on the screw shaft. The recoil of the gun incident upon the firing, throws the nut upon the bearing side of the thread, and tightens the disc against the circumscribing drum, absorbing the force of the recoil as the nut traverses down the revolving shaft, with a rapidity regulated by the adjustment of the brake strap.

In running out the gun, the carriage is raised at the rear end upon the rollers off the slides by a hand-

spike, the same motion, by a connecting link, throwing the running-out wheels into gear with a pinion inside the carriage, which works into a slotted rack cut into the side plate of the slide along its whole length. This gearing is worked by hand in the usual manner. So soon as the carriage begins to travel the friction brake is released, so that the disc and drum offer no resistance. When the carriage is xtended its full length it is lowered again on to the slides, and the running-out wheels are thrown out of gear.

The recent trials had for their object the testing of the carriage rather than the gun. The following table gives the results in a condensed form:

	Elevation.		Charge.	Compressor.	Recoil.	
	deg.	min.	lb.		ft.	in.
Round 1	5	3	14	7-10	3	7
" 2	5	3	14	13-20	4	0
" 3	5	3	22	15-20	2	5
" 4	5	3	22	29-40	2	11
" 5	8	0	22	7-10	3	8¼
" 6	8	0	22	7-10	3	6
" 7	8	0	22	7-10	3	4¼
" 8	2	30	22	4-5	1	0

The gun and carriage will be doubtless submitted to official trial, which will help to decide the comparative values of steel and iron as a material for heavy ordnance. Experience has shown in the tests of the Woolwich guns that a steel tube reinforced strongly by a wrought-iron casing remains serviceable, after its bore has become flawed, and its material considerably weakened, by means of the tensile strength of the surrounding metal, which is exerted in the direction of the strain upon the steel tube. The saving of weight in steel ordnance does not represent a corresponding saving in cost. A lengthened experience must decide that a large balance remains in favor of steel as an exclusive material for guns before the Woolwich system of manufacture is superseded.—*Engineering.*

COMPARATIVE CASUALTIES OF WAR.—The *Revista Militar*, of Lisbon, contends that the perfecting of firearms, far from increasing the mortality in battles, has, on the contrary, diminished it, and alleges the following instances: At Austerlitz the French lost 14 per cent., and the Austrians and Prussians respectively 14 and 30 per cent. of their soldiers. At Moscow the French loss was 37, while the Russian loss was 44 per cent. At Wagram the casualties were, among the French 13, and amongst the Austrians 14 per cent. At Bautzen the French lost 13, the Russians and Prussians 14 per cent. At Waterloo the losses of the Allies were 31, and of the French 36 per cent. Then comes the contrast. At Magenta the French lost but 7 per cent. of their troops, and the Austrian percentage did not exceed 8, while at Solferino the losses of the combatants were 10 and 8 per cent. It is hardly fair to compare the battle of Murfreesborough with those of regular armies, but according to the report of Gen. Rosencranz, which caused some surprise at the time it was published, 20,000 discharges of cannon put only 728 men *hors de combat*, and out of 2,000,000 musket shots no more than 13,330 took effect. It thus took 27 cannon balls and 150 bullets, or about 252 lb. of metal to disable each soldier.

TROWEL BAYONETS.—The 200 patent trowel bayonets, which have been making at the Springfield armory, will soon be placed in the hands of troops for trial.

THE BRITISH IRON-CLAD FLEET. ITS COST. According to a Parliamentary return just issued, it appears that the number of iron-plated ships afloat is thirty-four; there are also ten building. Of four floating batteries, two are not yet completed for sea. Of the number of armor-clad ships afloat, fourteen have iron hulls; the following are only partially armor-clad, viz: The Black Prince, with 28 guns, tonnage 6,109, horse power 1,250; Warrior, 32 guns, tonnage 6,109, horse-power 1,250; Defence, 16 guns, tonnage 3,720, horse-power 600; Resistance, 16 guns, tonnage 3,710, horse-power 600; Achilles, 26 guns, tonnage 6,121, horse-power 1,250; Hector, 18 guns, tonnage 4,089, horse-power 800; Valiant, 18 guns, tonnage 4,063, horse-power 800; Northumberland, 28 guns, tonnage 6,621, horse-power 1,350; Bellerophon, 15 guns, tonnage 4,270, horse-power 1,000; Hercules, 14 guns, tonnage 5,234, horse-power 1,200; Penelope, 11 guns, tonnage 3,096, horse-power 600; Waterwitch, 2 guns; Viper, 2 guns; Monarch, 7 guns. Five of those afloat with iron hulls are wholly armor-clad, viz: the Minotaur, with 26 guns, tonnage 6,621, horse-power 1,350; Agincourt, 28 guns, tonnage 6,621, horse-power 1,350; Prince Albert, 4 guns; Scorpion, 4 guns; Wivern, 4 guns. The Vixen, with 2 guns, has her hull built of both wood and iron, and is only partially armor-clad. Eight of the ships afloat have wooden hulls, but are wholly armor-clad, viz: the Royal Oak, with 24 guns, tonnage 4,056, horse-power 800; Prince Consort, 24 guns, tonnage 4,045, horse-power 1,000; Caledonia, 24 guns, tonnage 4,125, horse-power 1,000; Ocean, 24 guns, tonnage 4,407, horse-power 1,000; Lord Clyde, 24 guns, tonnage 4,067, horse-power 1,000; Lord Warden, 18 guns, tonnage 4,080, horse-power 1,000; Favorite, 10 guns, tonnage 2,094, horse-power 400; Royal Sovereign, 5 guns, tonnage 3,765, horse-power 800. Six of those afloat have wooden hulls, and are only partially armor-clad, viz: the Royal Alfred, with 18 guns, tonnage 4,068, horse-power 800; Zealous, 20 guns, tonnage 3,716, horse-power 800; Repulse, 12 guns, tonnage 3,749, horse-power 800; Pallas, 8 guns, tonnage 2,372, horse-power 600; Research, 4 guns; Enterprise, 4 guns. This formidable fleet of iron-clads afloat represents in the aggregate 520 guns. Out of the thirty-four vessels afloat thirteen are built on Mr. Reed's plan and five on Captain Coles's turret plan. The first cost of some of the iron vessels now complete, including fittings, but exclusive of incidental and establishment charges, was as follows: Northumberland, £459,109; Minotaur, £452,827; Agincourt, £446,115; Achilles, £444,590; Warrior, £356,990; Black Prince, £357,993; Bellerophon, £343,076; Prince Albert, £201,613. The cost of some of the wooden vessels was :—Lord Clyde, £273,824; Lord Warden, £316,837; Royal Alfred, £269,370; Ocean, £253,813; Caledonia, £264,658; Prince Consort, £226,995. Of the ten ships building, seven have iron hulls and are only partially armor-clad, viz: the Sultan, with 13 guns, tonnage 5,226, horse-power 1,200; the Captain, 6 guns, tonnage 4,272, horse-power 900; the Iron Duke, 14 guns, tonnage 3,774, horse-power 800; the Audacious, 14 guns, tonnage 3,774, horse power 800; the Invincible, 14 guns, tonnage 3,774, horse-power 800; the Vanguard, 14 guns, tonnage 3,774, horse-power 800; the Hotspur, 2 guns, tonnage 2,637, horse-power 600. The Glatton, with 2 guns, has an iron hull, and is wholly armor-clad. The Swiftsure and the Triumph have their hulls of iron sheathed with wood. They are to carry 14 guns each, with a tonnage for each vessel of 3,893; horse-power 800 each. These ten ships represent in the aggregate 107 guns. Two are to be built on Captain Coles' plan, and eight on Mr. Reed's plan. The estimated first cost of the Captain is £335,000, that of the Audacious £222,657, that of the Invincible £221,757, and that of the Vanguard £249,759. The names of the four floating

batteries—three of which have iron hulls and are wholly armor-clad—are the Erebus, with 17 guns; the Terror, with 16 guns; and the Thunderbolt, with 16 guns; the Thunder, with 14 guns, has a wooden hull, but is wholly armor-clad. The first cost of these batteries is thus stated:—Erebus, £82,039; Terror, £80,726; Thunderbolt, £80,230; Thunder, £59,776. The above 48 ships and batteries represent in the aggregate 689 guns, and horse-power of 35,290.

THE WILSON GUN.—A contemporary states that this gun is on the bolt principle, and of the most simple, direct and rapid arrangement. It requires but two movements to open and close the breech for firing; or, in other words, four motions for drill—namely, opening, loading, closing, firing—a bar extractor attached to the body of the bolt withdrawing and ejecting the cartridge-case in the one act of withdrawing the breech bolt. This bolt is fixed in position by a locking, or double lugg handle, situated on its rear end, and having a motion of partial rotation on entering the shoe-cap as the breech is closed. It is thus self-locking and securing; the double luggs engaging with the solid sides of the shoe-cap sustains the bolts firmly against the recoil. The gun has neither external lock, hammer, nor other projections, but the bolt itself contains a piston or striker operated upon by a strong spiral spring, the spring being liberated by the trigger depressing a flat guide or retaining spring placed underneath the shoe. The firing arrangement is very properly supplemented with a trigger stop of exceedingly simple and effective construction—namely, a hinged flap or plate, which, turned against the shank of the trigger, absolutely prevents its movement in any direction to discharge the gun.

SEA-GOING TURRET SHIPS.—"Engineering" (March 12, 1869) illustrates a new vessel of this class, designed by Admiral Paris for the French navy. It is a ship to carry two heavy guns, but it has only one turret, and is protected by armor only 5.9 in. thick on the vertical sides of the ship, 1.57 in. on the outside bridge, and 1.18 in. on the interior. The vessel is specially designed to carry sails, and would have three masts, by which the somewhat scanty power provided would be helped out. The following are the principal dimensions of the design:

Length of hull at water line	224.68 ft.
Outside width	50.84 ft.
Proportion of width to length	1 to 4.3
Width of ship inside	29.52 ft.
Proportion between interior and exterior width	1 to 1.72
Outside diameter of turrets	26.24 ft.
Calculated draught of water fore and aft	16.40 ft.
Volume of parallelopipedon	187,301 cub. ft.
Surface of the circumscribed rectangle at water line	11,416 sq. ft.
Surface of the circumscribed rectangle at midship section	827.80 sq. ft.
Displacement	110,214 cub. ft.
Weight of displacement	3075 tons.
Immersed midship section	713.8 sq. ft.
Area at water line	8600 sq. ft.
Proportion. Of the volume of the hull to the parallelopipedon	0.588
Of the flotation surface, to the circumscribed rectangle	0.754
Of the midship section, to the circumscribed rectangle	0.857
Height from the water level to upper bridge	10.16 ft.
Height from main deck to sill of turret ports	2.62 ft.
Height of turrets	19.35 ft.
Thickness of plate of the armored zone,	5.9 in.
Height above water line	1.96 ft.
Depth below water line	4.92 ft.
Total	7.88 ft.
Proportion of armor above and below the water	1 to 2.5
Weight	356 tons.
Number of towers	1
Height of armor on ditto	7.28 ft.
Thickness of plate	.984 in.
Weight of armor	78 tons.
Total surface of towers	806 sq. ft.
Weight of lower belt (3.28 ft. high and 1.18 in. thick)	58 tons.
Weight of upper ring (984 in. thick),	97 tons.
Total weight of towers	155 tons.
Total weight of armor	776 tons.
Nominal horse-power	400
Number of guns	2
Total weight of armor per gun	388 tons.

Summary of Weights.

Armor	776 tons.
Engines	324 tons.
Guns	80 tons.
Masts, sails, etc	50 tons.
Stores, etc.	40 tons.
Water and tanks	20 tons.
Miscellaneous	8 tons.
Machinery for turning turret	24 tons.
Coal at the estimated draught of water,	279 tons.
	1601 tons.

THE MONITORS.—The following comments are made by a correspondent, upon the article compiled from "Engineering," in the first number, page 33 of "Van Nostrand's Magazine:"

The article begins with a numbered statement of the "advantages of turret ship." Respecting statement No. 1, instead of having "no masts," monitors, whenever necessary, do have masts. Case, "Monadnock." Her sail-power was sufficient to propel her five knots in a good breeze. There is no difficulty in applying sails to monitors. An official sail draught for one of our large monitors shows a spread of some 15,000 square feet of canvas, sufficient to propel the vessel nine or ten knots in a good breeze. The fact (in case of a monitor) of "having its guns and much of its armor further inboard," is by no means the reason why the monitor "rolls less than the broadside ship." The chief reasons are the position of the *metacenter*, as compared with the center of gravity of vessel, and of the displacement. Think of the immense area of water line section of monitors compared with their *length* and *displacement*. As to facts (observed) in relation to comparative rolling of our monitor and British broadsides in equal weather, the broadsides roll through an arc *three times* greater, hence from this point alone the depth of armor of a monitor below water—for equality of impregnability—*need be but one-third that of a broadside*. Putting masts on a monitor of the height and weight necessary for respectable sailing-power does not raise the center of gravity of the *mast* sufficiently to have a perceptible effect on rolling.

2d. Respecting "Engineering's" estimate of "advantages of the broadside system," No. 1 says "they can carry masts!" *Per contra*, monitors have carried, and can carry them with safety. The statement that "a ship with a high freeboard will roll through an angle at which a ship with a low freeboard would capsize, from the weight of water on one side of deck," must have been made without proper calculation, or else on improper models. The pressure (and it is a heavy one) which would produce a heel of 18° on the Bellerophon would not produce a heel on a monitor of similar displacement of 7°!. This

is no guesswork, but fact—the result of easily-made calculation.

Next respecting "artificial ventilation." This is, in fact, the only way, in a sea-going vessel, that decent ventilation can be had in bad weather, and in good weather, even with a low freeboard "open air exercise" at sea is possible. Think of the atmosphere in the cabin of the best of the English ships in bad weather when they are compelled to screw everything up tight! "Artificial ventilation" is one of the chief features in the "Stevens' battery," and a first-class feature it is, too. The atmosphere on the berth-deck of a frigate like the Roanoke was, in bad weather, with hoods on the hatches, only comparable to the Black Hole of Calcutta. Artificial ventilation, for sea-going purposes, is an American invention, and John Bull cannot cough it down any more than he could a 15 in. shot with 100 lbs. charge, and some 13,000,000 ft. lbs. of *vis viva*, which McAdamized his 8 in. solid slab, 18 in. backing and inner skin. What will he do against a 20 in., with some 22,000,000 ft. lbs.? High freeboard and 22 million ft. lbs. in shot scarcely make a good comparison.

3d. "The ship with a high freeboard carries its guns higher out of water." With either a central fixed tower (guns in casement), or a turret, the guns may, if necessary, be carried equally high. I have seen a plan of turret which carries its gun 10 ft. from the water, and that, too, without adding much weight. The celebrated Bellerophon only carries her gun 9½ ft.

4th. "Engineering" further says: "Yet consider for a moment what a ship Ericsson designed to build—the Dictator—to carry two guns in a single 24 ft. turret, 9 ft. high and 15 in. thick * * * has a tonnage of 3,000 and a displacement of 5,000 tons * * * the boilers have far more grate area and heating surface than any vessel in the English navy." Now, the Dictator's displacement is inside of 4,500. The mistake of 500 tons is more than enough to make the turret 3½ ft. thick, and allow for two 20-inch guns inside of it. As her side armor is 10½ in. iron, 40 to 42 in. oak, besides inner skin, what broadside vessel of double her displacements yet built could whip her?

FILTER VANS AND CARTS FOR INDIA.—The scarcity of good drinking water is well known to be one of the most serious hardships of our army in India. It is notorious to every one of Indian experience that the soldiers are occasionally dependent on supplies literally poisonous and unfit for use, and the prevalence of cholera and other diseases has been distinctly proved to have been attributable to this cause. The authorities are now examining an important invention, manufactured by Messrs. E. H. Bayley & Co., the large wheelwrights of Newington Causeway, designed with great skill to meet this great want, and which seems admirably adapted to the purpose. It consists of a bullock van or cart on springs, containing a galvanised iron cistern, capable of holding about 250 gallons of water. The van is surmounted by a portable pump, by means of which the cistern may be filled from a pond, stream, or other source of supply. As the water when first pumped in may be very impure, the sediment is made by a simple arrangement to fall into a separate well or trap at the bottom of the van, whence it is drawn off by a cock. The water thus partially purified, next passes by a pipe into a second well, where it flows underneath two large filters, through which it is forced to percolate upwards. The value of this system of filtration by ascension is obvious, as the thicker impurities do not rise in the water, and consequently are drawn off by a cock without approaching the filters at all. Should the water be very impure, it can, by an ingenious contrivance, be made to pass, first through one filter, and then the other, and thus be doubly purified. After passing through the filters, the purified water flows into reservoirs, whence it can be drawn off into drinking cans from a row of brass taps at the back of the van. As fast as the water is pumped in at one end of the van, it is thus drawn off pure and filtered at the other. The cistern is thoroughly protected by an outer casing from the rays of the sun and kept cool.

These vans will be useful in our own camps, but will be a great boon to the army in some parts of India. We understand the patentees have received considerable orders from various foreign governments. While the House of Commons spends millions on guns and fortifications, it will assuredly not begrudge the few thousands that will suffice for supplying every regiment in India with what will be invaluable for the health and lives of our countrymen.—*Army and Navy Gazette.*

EFFECT OF THE CHASSEPOT BULLET—ERRONEOUS REPORTS.—Dr. Gason, of Rome, reports as follows regarding the effect of different bullets at the engagement at Montana, in November, 1867: The lightness of the Chassepot firelock and its loading at the breech caused a far greater proportion of wounds in the upper part of the body than was the case in those wounded by balls from the muzzle-loaders.—The entrance made by the Chassepot ball was very small; the exit not much larger. There was much less effusion of blood beneath the skin than in wounds by the round ball or Minié. The long bones were more frequently split. The immediate effects of the Chassepot were more fatal; but the ulterior effects less severe and fatal in wounds produced by the Chassepot than in those of the round ball or Minié. The external hemorrhage was greater in wounds produced by the Chassepot ball than by any other form of projectile; and in those places where the Italians fell when struck by it, there were large pools of blood.

Among the cases brought into the hospitals in Rome, there was not one where the wound produced by the Chassepot bullet bore any proportion to that mentioned in the report from the camp at Lyons—that "the exit was as large as a person's two fists." It would appear from the reports from the camp at Lyons, that in most instances the bodies of dead animals were used for the experiments.—*The Lancet.*

THE FRENCH NAVY.—The French fleet was composed on the 31st December, 1868, of 430 vessels, of which 231 were steamers with a total of 76,165 horse power. There are, besides, in course of completion afloat, 7 others of 3,710 horse power, and on the stocks 31 more of 12,405 horse power, and one sailing transport. This total is divided into two distinct portions, the first including the vessels which form part of the new fleet, to be constituted in accordance with the programme in course of execution since 1857; and the second, composed of the remains of the old navy, considered unfit to take place in the new, either directly or after transformation. The new naval force, the only one that constitutes the real maritime strength of the empire, counts as completed 314 steamers and 10 sailing vessels. A table shows: (1) iron-clads to the number of 50 of various classes; (2) the unarmored fighting ships, 96 screw steamers; (3) 91 small steamers, despatch boats, tenders, &c.; (4) transports, 95 of various sizes; and finally, the two training schools, one for gunners and the other for naval pupils. Of the old fleet there still remain 17 steamers and 29 sailing ships.

ARMOR PLATES, made by coiling bars of iron as for Armstrong gun tubes, welding the coil by upsetting, cutting the coil in two, and flattening out the halves into plates, has proved a great failure, as the experts prophesied. The welds were found very defective.

THE NEW CHALMERS TARGET.—The recent death of Mr. James Chalmers lent a melancholy interest to the experiments which were lately carried out at Shoeburyness, with the last target designed by that gentleman. Although considerable hopes were entertained of the new target, they were not realized on the present occasion, the target having been pierced in every direction with the projectiles which were directed against it. Our readers are so well acquainted with the details of the Chalmers target, that it is unnecessary here to repeat them. It will be sufficient to state that the target lately experimented on was 15 ft. long, by 9 ft. high, the face being composed of two 4½ in. armour plates of the same length as the target, and 4 ft. 6 in. deep. The target was 2 ft. 9¼ in. thick, including the angle iron ribs at the back. Mr. Chalmers had introduced eight modifications of backing, so that the target was divisible into as many different parts, each representing a modification of the general principle. A "Warrior" target had been made, and was placed beside it for enabling comparative results to be ascertained. The firing was from a 9-inch muzzle-loading rifled gun, with 250 lb. projectiles and 43 lb. powder charges, the range being 200 yards. As the trial, unfortunately, proved only the failure of the Chalmers target, it is unnecessary to follow closely the details of firing. Eight rounds in all were fired, five with solid shot and three with live shell. Rounds 1, 4, and 5 with solid shot were directed against the "Warrior" target, through which they failed to pass. Round 1 knocked a piece out of the edge of the target, and rounds 4 and 5 penetrated the target, but remained in it. Rounds 2 and 3 with solid shot were fired at the Chalmers target, through which they passed clean out to the rear. The first live shell struck the "Warrior" target, making a hole 2·23 inches deep, whilst the second and third shells passed through the Chalmers target, and burst in the rear. It was thus made apparent that the face plate of the latter target was much too weak for the work it was designed to do, and that in effect Mr. Chalmers had pushed his principle of elasticity too far. There is no question of the soundness of the principle, but the extreme lightness of the outer plate neutralized any effect obtainable from the backing. It is to be regretted that such a mistake in the designs of this target should have been made, and still more that the inventor is not here to profit by it, and to bring the labor of years to a successful issue.—*Mechanics' Magazine.*

THE HERCULES AT SEA.—Satisfactory reports have been received of the performances of the iron-clad Hercules on her voyage to Lisbon. Although dragging her large screw propeller, she several times exceeded a speed of ten knots under canvass, and performed the operation of "staying" with great ease. The whole consumption of coal upon the voyage was less than fifty tons, or one-twelfth of the quantity on board. She is also a very steady ship, rolling and pitching exceedingly little, not only under a press of canvass, but with a beam-sea running and little wind. The huge guns (each weighing 18 tons) were worked and fought every day with perfect success.

ENGLISH OAK—THE WOODEN WALLS OF ENGLAND.—The timber-built unarmed screw frigate Sutlej, is now having her machinery taken out at Portmouth, preparatory to being broken up. It was only in October, 1860, that the Sutlej made her first speed trial as a new ship over the measured mile, when she attained a mean rate of 13.076 knots. She was then considered one of the handsomest and swiftest ships afloat. She is now a striking illustration of the short life and costliness of a wooden-built ship of war.

A NEW NEEDLE GUN.—The Berlin correspondent of The London "Daily News," writes on Jan. 9: About a week ago the "Vossische Zeitung" astonished its readers with a paragraph announcing the invention of a new rifle, called the Zundwassergewehr, or ignition water gun. Although the experience of the last few years has prepared us for all sorts of wonders in the way of firearms, yet ignition water seemed an enigma which could only be solved by the man who knows how to set the Thames on fire. The passage was copied in other papers, and will probably excite no little interest in other parts of the world, until the prosaic explanation of a misprint has cleared up the difficulty. The real name of the invention in question is a "Zundmessergewehr," or an ignition knife gun. It appears that the cartridge is made of some peculiar kind of paper, and that it explodes when cut by a knife. This sounds very dangerous, but I must assume that a knowledge of the details would show that the ignition is not so simple as it seems. Lieut. Col. Count Lehndorf, one of the King's Adjutants, has tried the new rifle at the Hasenhaide range, near Berlin, in company of the inventor, Herr Meyhofer, a Prussian country gentleman, and the results were very satisfactory. Herr Meyhofer succeeded, in two experiments, in hitting the target 13 times in 36 seconds. Another wonderful invention is reported from St. Petersburg. A Russian officer has constructed a cannon which can fire 200 shots in a minute. It is extremely easy to handle, and very effective up to 1,800 yards.

A NEW GUNPOWDER.—A new composition of gunpowder is being tried in the French army and navy. The inventor, a M. Dessignolle, has substituted for sulphur the picrate or nitro-carbonate of potassa. The picric acid is a new compound, obtained from the mixture of phenic and nitric acids. The picric acid explodes by the heat, and there results nitrogen, carbonic acid, hydrogen, water, carbon and carbonate of potassa.

$$(C_{12}H_2K(A_3O_4)_3O_5=3Az+5CO_2+HO+H+6C+KO\,CO_2)$$

The smoke produced is trifling, and the absence of sulphur makes it injurious neither to the men nor to the weapons. Besides that, when the powder is made only from picrate and nitrate of potash without carbon, a very violent powder is obtained, which is excellent for blasting. It has nearly the same strength as the nitro-glycerine, and seems to be less dangerous. The absence of smoke will be a notable improvement for tunnelling. It is probable that, when regularly manufactured, this new powder will be obtained at the same price as the ordinary gunpowder.

NOVEL GUN CARRIAGE.—A gun carriage and slide of a novel and very ingenious construction, by Messrs. Vavasseur, of the London Ordnance Works, for a 7-inch steel built-up rifled gun, was tested recently at Yarmouth, with the highest success. The compressor, which is the most important feature, consists of a cone and drum, working under a brakestrap, this friction gear being attached to the head of a long screw-shaft, actuated by a nut under the carriage, moving along it and turning it round. The great value of the system is that the compressor is always ready to be acted upon by the recoil, and is automatically put into gear the moment the gun carriage begins to move.

DEPTFORD DOCKYARD, which will be closed this year, is one of the most ancient dockyards in the kingdom—an old monastery, bearing date 1513, still stands in the yard, and is used as a storehouse. It was at Deptford Dockyard that Peter the Great learned the art of shipbuilding. The present strength in the yard is under 500 hands. The regular working strength is 841.

COST OF HEAVY GUNS.—The Ordnance Committee have discovered that the army Rodman 15-inch gun costs $6,500 each, for 49,000 lb. weight. The navy guns of the same caliber weighed 42,000 lb. The difference in weight, at 13 cents per pound, makes $910, which the navy paid more for their guns than was paid by the army. The navy contract with the Fort Pitt Foundry provided for the delivery of all guns on the seaboard at the expense of the maker, yet the Government paid for all this transportation. From the spring of 1864, all 15-inch guns procured at Pittsburg were taken without any powder proof, according to an order from the Chief of Ordnance. Therefore, guns procured since that time have been mounted in fortifications on expensive iron carriages, without being fired at all; and lately an order was issued from the Ordnance Department to subject them to a proof of charges of 100 lb. of powder, at the risk of the Government.—*Washington telegram to Philadelphia Inquirer.*

ORDNANCE AFFAIRS AT WOOLWICH ARSENAL.—Arrangements are being made for the construction of iron gun carriages for the navy at the Chatham Dockyard, though recently certain buildings in the Royal Carriage Department, Royal Arsenal, had been altered and fitted up with plant and machinery to carry on the works at a great cost. The removal of the naval carriages to Chatham will lead to part of the Carriage Department being closed. In the Royal Gun Factory Department, the Armstrong branch has been shut up for a considerable time with all its expensive machinery, in consequence of a large order being given for the conversion of guns from the smooth bore into rifled guns upon the Palliser principle, to be effected at the Elswick Factory, instead of at the Government establishment at Woolwich.—*Mechanics' Magazine.*

PALLISER'S PROJECTILES.—In a recent report of the Ordnance Select Committee are the following results of the penetrative power of shot and shell, fired from heavy rifled guns at a range of 70 yards. A Palliser shell weighing 398 lb., fired from a 10-in. muzzle-loader of 18 tons, with a charge of 54 lb. of powder, penetrated through 23 ft. of earthen parapet, and passing out in an upward direction continued its flight for 300 yards beyond. A 9-in. Palliser shot, weighing 248 lb., fired from a 9-in. 12 ton muzzle-loading gun with a 37 lb. charge, nearly passed through 23 ft. of earthwork, the point of the shot showing through the further side of the parapet.

KRUPP'S CANNON FOR PRUSSIA.—A large order for the 9-inch cannon which performed such extraordinary feats at Tegel has been given Mr. Krupp by the Prussian Government. The bill is expected to amount to 4,000,000 thalers, each barrel costing somewhere about 30,000 thalers. The same gun has just been adopted by the Belgian Government, to be placed on the walls of Antwerp. According to official intelligence received here, experiments made with the 9-inch cannon in Belgium resulted in the Bellerophon target being totally destroyed after eight rounds, the Warrior target having endured but seven.

AUSTRIAN IRON-CLAD.—The largest iron-clad in the Austrian navy—the largest ship probably ever launched in the Adriatic—has just been launched at Trieste. She is called the Lissa. The ship is built ent rely of Austrian materials, and every detail of her machinery and armament will be Austrian. Her length is 272 ft.; breadth, 45 feet; displacement, 6,000 tons. Here engines are of 1,000-horse power, and her armament will be twelve 300-pounder Krupp guns.

NEW BOOKS.

A RUDIMENTARY TREATISE ON THE MANUFACTURE OF BRICKS AND TILES; CONTAINING AN OUTLINE OF THE PRINCIPLES OF BRICKMAKING. By EDWARD DOBSON, A. I. C. E., M. I. B. A. Revised and corrected by CHARLES TOMLINSON, F. R. S. Fourth edition. With additions by ROBERT MALLET, A. M., F. R. S., M. I. C. E., &c. With illustrations. London: Virtue & Co. New York: Virtue & Yorston. 1868.

The name of the author of this treatise is a sufficient guarantee that the contents will answer the expectations of the reader. If the "claims of long descent" are supposed to be of any importance to a building material, then bricks certainly take the foremost rank, and in all probability their future career will be as endurable as their past. It is true that the employment of stone, where works of great magnitude are concerned, becomes almost imperative, both for constructive reasons, as well as for the sake of æsthetical effect; but it will never supersede the more ancient material in structures of a smaller and less pretentious character. That there is an enormous amount of bad brickwork hourly erected in London and elsewhere, no one who is acquainted with the manner in which houses are run up by speculating builders will for a moment deny. At the same time, there are not wanting numerous examples of the same description of work which have withstood for centuries the attacks of the weather and the influence of time, and remain to the present day indisputable witnesses to the solidity and durability that is, or rather was, possible to obtain by that method of construction. But in those earlier times bricks were bricks and mortar was mortar. Mud and slime were unknown quantities.

As might be reasonably anticipated, it was not long after the introdnction of machinery before its potent aid was called in to assist in the manufacture of bricks, and so far as their crushing strength is concerned, it appears that the machine-made brick will stand about one and a half times the weight that will crush the best hand-made specimens. In the manufacture of bricks, as well as in all artificial preparations, the success of the operation and the value of the product are chiefly dependent upon the selection of the material; consequently the selection and the preparation of the clay of which the bricks are composed demands not merely care and attention, but also experience on the part of the manufacturer. Next to this, the management of the kiln is an important detail in the process. From chapter I, which treats of the manufacture of bricks and tiles in Holland, and which is contributed by Hyde Clark, C. E., it seems upwards of a million bricks are sometimes burnt in a Dutch kiln. The Dutch have long been famous for their clinkers and other bricks of a hard description. Notwithstanding that the principle of brickmaking is everywhere identical, a great diversity exists in the various lesser operations connected with their production. The nature and extent of these vary with the district and locality where the manufacture is carried on, and the several methods practiced in the vicinity of the metropolis, in Nottingham, Staffordshire and other provinces, are fully described and investigated.

In addition to the regular established manufacture of these materials of construction at well known places, they are frequently made in large numbers in what might be termed an impromptu manner. Wherever any great excavation takes place, such as that for a large tunnel or dock, which requires to be "lined," the bricks for "lining" it are generally made upon the spot, provided that the earth be in any way suitable for the purpose. All that is wanted in a brick intended for tunnels, docks and other engineering works is, that it should be hard and sound,

should ring well when struck, and not be too absorbent. Irregularity in shape and want of uniformity in color, however detrimental to house bricks, are of little or no consequence where strength and stability are the only features sought for in the building they compose. Chapter IX is devoted to a description of the different machines invented for facilitating brickmaking, and is well deserving the perusal of all interested in the subject. The illustrations are especially well executed, and are distributed with no sparing hand. In the appendix at the close of this valuable little volume there is a short chapter upon the science of brickmaking, in which the chemical nature of the operations, the composition of the various clays employed, and the effect of the combination of the several ingredients, are examined into. The publishers, in the production of the fourth edition of this well known treatise, have fully sustained in every point the acknowledged reputation of their firm, and also the value of the "Rudimentary Series."—*The Engineer.*

A Treatise on Optics, or Light and Sight, Theoretically and Practically Treated, with the Application to Fine Art and Industrial pursuits. By E. Nugent, C. E., Ex-principal of Commercial, Nautical and Engineering College, New York. London: Virtue & Co. New York: Virtue & Yorston.

This Treatise on Optics, by Mr. Nugent, is just one of those books calculated to demonstrate that the principles of this science, and, in fact, of any other, may be taught in a manner that can be readily comprehended, both by persons of limited information and of limited abilities. It must not be gathered from our statements that we recommend, or at all indorse, an unstudious or dilettante style of perusing a treatise on a scientific topic. * * * Starting with the definition of light, Mr. Nugent briefly refers to the various theories—ancient and modern—entertained upon that question, and it will be sufficient to remark that the wave or undulatory theory is now the usually received one among scientific men. It is true that the emissive theory still has its advocates, but it no longer meets with the universal acceptance it once did. The three chapters immediately following the first are devoted to an elucidation of dioptrics, or that branch of the science relating to the refraction of light. By the aid of several excellent diagrams the subject is fully and lucidly explained, including the formation of images by prisms and lenses. The one principal law of catoptrics, or that branch embracing the reflection of light, is that the angle of incidence is equal to the angle of reflection; and when this is understood, all the questions relating to the reflection of mirrors will be easily comprehended.

After perusing the chapter on caustic curves, which are practically and familiarly explained, we are introduced to physical optics, including the composition of light. This is one of the most interesting portions of the volume, and the various opinions put forward, and the experiments bearing upon the sevenfold or threefold composition of light, candidly and fairly investigated. Most of our readers are familiar with the solar spectrum, which, according to Newton, consisted of seven, and to Sir David Brewster, of only three primary colors, red, yellow and blue. The latter philosopher accounts for the mistake into which he considers his scientific predecessor to have fallen, by attributing it to some imperfection in the manner of conducting his experiments. Be this as it may, the composition of white light may be regarded as consisting of the three colors only. A description of the eye, together with the laws of vision, and color-blindness, absorb chapter VIII. Under the head of "Optical Instruments" are explained most of those pleasing delusions, including the celebrated "Pepper's ghost." The details of the various descriptions of telescopes—the Newtonian, Gregorian, Gallilean and Herschellian—are illustrated by suitable diagrams, and a chapter upon the application of optics to the useful arts brings to a close this valuable addendum to our repertoire of books calculated to diffuse information and instruction among our artisans, and all who desire to become acquainted with the true principles of science. We may congratulate the publishers upon having produced a volume handy in size, neat in appearance both externally and internally, and admirably adapted for fulfilling the purpose which the author mentions in his preface was that which he had in view.—*The Engineer.*

Scientific Studies; or, Practical, in Contrast with Chimerical, Pursuits: Exemplified in two Popular Lectures. By Henry Dircks, C. E., LL.D. Post 8vo. E. & F. N. Spon.

The first of these lectures is on the Life of the Marquis of Worcester; the second on Chimeras of Science. We have here an epitome of Mr. Dircks' larger memoir of the Marquis of Worcester, bringing together for the first time, in a popular form, what has never hitherto been accomplished; that is, a truthful notice of facts in connection with the life of the undoubted inventor of the steam-engine. Previously it had been the custom to supply every hiatus with some vague surmise or other, and, as each writer exercised his ingenuity as best he could, it became at length difficult to ascertain where the truth lay. Some declared he wrote his "Century" while confined in the Tower, others supposed he wrote it in France; Mr. Dircks shows that he wrote it after his release from imprisonment.

Mr. Dircks seems to be quite at home on the Chimeras of Science. He refers to various works on astrology, alchemy, and mathematical and mechanical chimeras, not omitting his own "Perpetuum Mobile; or, History of the Search for Self-Motive Power"—a work likely to be highly useful to young mechanics at their studies, and to older ones who have neglected them. Mr. Dircks concludes that—"Astrology is merely a philosophism, being empirical, wholly visionary, a mere fanciful system, compounded of incongruous mixtures of astronomical with human events, of mythology with theology, and of facts with pure fiction;" and that, while laying claim to the remotest antiquity, it makes no pretence to inspiration. Treating on alchemy, the author states that—"Alchemical writings are very numerous; they may be estimated at from 3,000 to 4,000 works, and an astonishing number of manuscripts." So insinuating was this delusion that Lord Bacon, Luther, Spinoza, Leibnitz, and many eminent moderns believed in finding the philosopher's stone, the gem of the Hermetic philosophy. Next follow the squaring the circle, duplication of the cube, trisection of an angle, and perpetuum mobile, illustrated by means of neatly engraved diagrams, to accompanying explanations. Among the squarers preference has been given to Mr. James Smith, of Liverpool, in plate 3. Arago declared that all that could be gained in computing "the area of the space included within a circle of thirty-eight millions of leagues radius may be determined within such a degree of precision that the probable error shall not exceed the space of a mite," or grain of sand, as others remark.

These lectures, notwithstanding their popular character, are replete with information, and cannot be read by the studious without satisfaction and benefit, as their author brings to bear on them a vast store of curious reading, and the result of years of practical experience.—*Mining Journal.*

Cours élémentaire de Physique. Par l'Abbé H. Cabiac. Paris.

THE LATHE AND ITS USES, OR INSTRUCTION IN THE ART OF TURNING WOOD AND METAL. (Anonymous.) 1 vol. 8vo. London: Trübner & Co., 1868.

A TREATISE ON LATHES AND TURNING. By W. H. NORTHCOTT. 1 vol. 8vo. Illustrated. London: Longmans, 1868.

There is no need to say much more of the second-named work than that it is a plainly written, unpretending and practical introduction to the use of the lathe, and instruction as to what may be done with it or by it, directly or indirectly. It deals not in the history or past phases of the turner's art, but with the actualities of the present day; and is illustrated, among other plates, with some views of lathes, &c., produced from photographs furnished by some of the very best makers, such as Fairbairn, Kennedy and Naylor, of Leeds, &c. This would be a good book to put into the hands of a lad commencing his apprenticeship in a tool-making or engineering shop. The first-named volume is still better—more exhaustive, and, we may say, a more scientifically written work, and better fitted for the advanced student of mechanical engineering. The author, who is probably an American, curiously enough thinks proper to conceal his name. He admits in his preface that a considerable proportion of his work consists in compilation from American journals; it may not be a bit the worse for this, however.

There are two appendices; one on the angles of tools, by Mr. Dodsworth Haydon, of Guilford; the other on a new arrangement of lathe and chuck to do rose engine work, by Elias Taylor, of Brighton. These, both by English authors apparently, are well written, and the latter is useful to the ornamental turner.

As to fine-spun theoretic dicta for fixing the angles of tools for various sorts of work, we confess we have not much respect for them, notwithstanding the names of Willis and Babbage, Holtzapffel, &c., with which such refinements have been connected. All of practical value on the subject of these angles can be stated in a few sentences, and becomes insensibly learnt by tact very soon by everybody. A razor, a wood knife, a wood chisel, a chipper for iron, a turning tool or drill, need different angles of edge; but we know so little of the nature of the resistance to division opposed by solids, or of the arrangements of their constituent molecules, that theory really decides little or nothing worth knowing as to the *limits* of best angle for various materials and different conditions.

The fact is, a turning tool, for example, will cut nearly any metal in the lathe at many angles of edge between 60° and 90°, and by varying speed and other conditions of application of the tool, and holding the latter with mechanical firmness, the same results may be obtained with larger variations of angle. For finishing *soft* brass the doctors fix the angle at 90°, *i. e.* a square scraping tool; but for turning *hard* steel or chilled cast iron the same, 90°, is not only the best but the only angle that will stand long. Where is the *principle* that gets at these extremes? The fact is, much as has been written—prattled, we are almost tempted to say—by theoretic amateurs on this subject, the very fundamental basis for any sound theory upon it remains to be discovered.—*Practical Mechanic's Journal.*

A PRACTICAL TREATISE ON MINE ENGINEERING. By G. C. GREENWELL, F. G. S. Second edition. London: Spon, 1869.

The first edition of this work was published fifteen years ago, and Messrs. Spon are doing good service in giving the world a second edition of a very valuable treatise, almost entirely rewritten, and published in monthly parts. It is always difficult to judge of the merits of a book from a small instalment of the whole; but Mr. Greenwell's reputation is one guarantee that the work will be good; the character of the first monthly part, now before us, is another, and Messrs. Spon's well-earned reputation is a third. The publishers supply a short prospectus, telling the world what the contents of the work are to be, viz: Geology, as applied to mining; classes of rocks commonly met with in mining for salt, coal and metallic ores; building materials; dykes, slips and mineral veins; internal heat; metallic ores and minerals associated therewith and with coal; smelting; boring and sinking tools; timbering; walling; tubbing; management of quicksands and clay; pumping engines and pumps; winding engines; ropes; pulleys; strength of timber; ropes and other materials; the working of mines; copper; lead; tin; iron; salt; coal; ventilation; theory and practice; fire damp; carbonic acid and other gases; explosions and other casualties, &c. The work will be illustrated with sixty-four large colored lithographs, four of which are contained in the first part. We must reserve a more extended notice of the work till it has made further progress towards completion. For the present it must suffice to say that Mr. Greenwell's information is accurate, and his style remarkably easy, and even elegant, while the style in which the work is got up by the publishers leaves little to be desired. —*The Engineer.*

SYSTEM OF NAVAL DEFENCES. By JAMES B. EADS, C. E. Report to the Honorable Gideon Welles, Secretary of the Navy. New York: D. Van Nostrand. 1868.

At the close of the American war, Mr. James B. Eads, an American engineer and shipbuilder, was commissioned to examine the naval constructions of Europe, and to report thereon to the Secretary of the United States Navy. The result of Mr. Eads' investigations were embodied in this report. In this document, after touching generally upon the question of naval construction, and paying a well merited compliment to Mr. E. J. Reed, our Chief Constructor, in respect of the "Bellerophon," the author goes on to criticise the turret system. But the gist of the report is the publication of the author's designs for having from one to five fixed turrets within which the gun platform revolves. Mr. Eads of course falls foul of Captain Coles and Captain Ericsson, considering the deck joint a radical defect. On the whole, the "report" is not what we expected to find it, considering its title. It is true the author submits it as "the result of his observations abroad," but having been commissioned "to examine the naval constructions of Europe," we should have expected something more than a little generalizing about European turret ships—which could be done by the author in his own office—and a great deal of particularizing about his own scheme.—*Mechanic's Magazine.*

The "Army and Navy Gazette" gives a long *resumé* of Mr. Eads' arguments, and compliments him on his forcible style of statement, but expresses no opinion on the merits of the case.

BRITISH RAILWAYS—AS THEY ARE AND AS THEY MIGHT BE. By JOHN IMRAY, C. E. London: E. & F. N. Spon, 48 Charing Cross. 1869.

Various schemes for vastly increasing the number of passengers by decreasing fares, and thus in the long run benefitting both the companies and the public, have been put forward. They are all too far advanced for our country and perhaps for our day. Mr. Imray's is less revolutionary than some that have been proposed, and the following abstract of it from the "Building News" will at least be entertaining:

The tickets for passengers to be issued by Government, like postage or receipt stamps, to be sold at any stamp or post office, and available on any day

and on any line. The tickets to be of two diffrent forms, and four colors—white for first class, red for second class, blue for third class, and yellow for luggage and parcels, these last to be adhesive. Square tickets to indicate a "short" journey, not exceeding twenty-five miles, and oblong tickets to indicate a "long" journey, over any distance greater than twenty-five miles. Every passenger while in a carriage to wear his tickets visibly attached by a hook or catch in his dress, so that the officers may see it. The prices of these tickets to be as follows:

	1*st class*.	2*d*.	3*d*.
Square tickets for short journeys..	1s.	6d.	3d.
Oblong tickets for long journeys...	10s.	8s.	4s.

Luggage tickets for any distance, 1s. each.

In cases where a line of railway belongs to two companies, and the first part traveled by a passenger does not extend twenty-five miles beyond a station where the passenger enters, the tickets to be collected and kept by the second company. In the case of long tickets the same system, but the second company to carry the passenger on to a distance of one hundred miles from the station where he started. Every railway company is to keep an account with a Government office—preferably a branch of the Inland Revenue Office—where the company is to obtain payment for its obliterated tickets, less a certain amount chargeable for duty.

CASSELL'S TECHNICAL MANUALS: ORTHOGRAPHIC AND ISOMETRICAL PROJECTION, DEVELOPMENT OF SURFACES, AND PENETRATION OF SOLIDS, &c. By ELLIS A. DAVIDSON, Lecturer on Science and Art in the City of London Middle Class Schools, and author of "Linear Drawing." Cassell, Petter & Galpin: London and New York.

A knowledge of orthographic projection is essential before the student can make working drawings of any bridge, house, roof or other example of construction, and this knowledge is only to be acquired by practically drawing the various diagrams and projections upon a tolerably large scale. * * *

This little volume commences with a description of the mathematical instruments ordinarily required by draughtsmen, and we heartily indorse the advice of the author, wherein he cautions his readers against bad and inferior instruments. It is always money well spent to buy the best tools, and no sensible person would ever think of doing otherwise. From the projection of single figures, the reader is gradually introduced to others of a more complicated nature, including the development of the cylinder and the helix. The last chapter treats on isometrical projection, a particular description of perspective delineation invented nearly fifty years ago by Professor Farish, of Cambridge. This is a very useful and at the same time a very characteristic style of drawing. It is admirably adapted for showing at a glance the *tout ensemble* of any architectural or engineering structure, the details of iron work or carpentry, and the general arrangement of details. At the same time it is not calculated to supply, strictly speaking, the place of working drawings. From the manner in which orthographic and isometric projections are treated in the volume under notice, we consider it well calculated to form a valuable little text-book for the draughtsman and beginner.—*Building News.*

A DESCRIPTIVE TREATISE ON MATHEMATICAL DRAWING INSTRUMENTS, THEIR CONSTRUCTION, USES, QUALITIES, SELECTION, PRESERVATION, AND SUGGESTIONS FOR IMPROVEMENTS; WITH HINTS UPON DRAWING AND COLORING. By WM. FORD STANLEY. (Second edition.) Stanley: London.

This is a second edition of Mr. Stanley's treatise on mathematical instruments, to which several additions have been made. Amongst other things a description is added of a drawing board in the form of a tray for holding wood blocks while drawings are being made on them; and a new form of copying table, consisting of a sheet of glass, on which the drawing to be copied is placed, a mirror being arranged below the glass so as to throw the light up through the drawing. A description is also added of Amsler's planimeter, an instrument that deserves to be more generally known, and of a form of set square used on the continent for drawing section lines. This set square is provided with an arrangement such that by pressing a lever with the finger the square is shifted a certain distance. Altogether, Mr. Stanley's book contains much information that will render it useful to young draughtsmen.—*Engineering.*

AN ELEMENTARY COURSE OF PLANE GEOMETRY. By RICHARD WORMELL, M. A., Medallist in Mathematics and Natural Philosophy (London), author of "Arithmetic for Schools and Colleges." London: Thomas Murby, 32 Bouverie street, Fleet street, E. C.

In reviewing this book the "Building News" says the author of this volume has succeeded in investing a dry subject with a considerable amount of practical attraction, and illustrates each point by an appeal to the common sense of the student, in a manner that at once enlists his interest and arrests his attention. Lines and planes, angles, circles and triangles are described in detail, and the T-square, the level, plumb line, and square introduced, to show the application they have to the rudiments of other branches of education, and how they bear upon many points of technical and professional training. At the end of every chapter a number of questions for self-examination are added, sufficient to enable the learner to fix, by means of their solution, the substance of the chapter in his memory.

THE MANAGEMENT OF STEEL. By GEO. EDE; employed at the Royal Gun Factories' Department, Woolwich arsenal. From the fourth London edition. New York: D. Appleton & Co., 1867.

The successive editions of this little manual have gradually increased from a small pamphlet to a goodly duodecimo of over two hundred pages, and we are glad to find that a reprint is accessible to our American workmen. As a practical worker in steel Mr. Ede stands very high, and his book affords evidence that he possesses the rarest of all faculties, viz: the ability to state plain facts in a plain manner. The result is that the book is crammed full of thoroughly practical directions and valuable suggestions.

Those who have carefully read the volume will, we think, agree with us when we say that, notwithstanding the unqualified praise which we have accorded to this book, it might be much improved if submitted to the editorial revision of some well-qualified person. In this way certain inelegancies, and consequently indefiniteness of expression, might be readily amended.—*Am. Journal of Mining.*

TREATISE ON VALVE-GEARS, WITH SPECIAL CONSIDERATION OF THE LINK-MOTIONS OF LOCOMOTIVE ENGINES. By Dr. GUSTAV ZEUNER. Third edition, revised and enlarged. Translated from the German by MORITZ MULLER. London: E. & F. N. Spon.

Dr. Zeuner's treatise has been received on the continent as the standard work on valve-gear. The work is divided in all into ten chapters, devoted to the consideration of the simple valve-gear, and to the link-motions of Stephenson, Gooch, Allan, Heusinger von Waldegg, and Pius Fink, and the valve-gears of Gonzenbach, Meyer and Polonceau. There is also an appendix of the book, treating of the counter-effect of steam in engines fitted with reversing gear.

Dr. Zeuner's valve diagram was described and illustrated in the first number (page 20) of *Van Nostrand's Magazine.*

ENGINEERING FACTS AND FIGURES FOR 1868. London and Edinburgh: A. Fullarton & Co. 1869.

The sixth annual volume of "Engineering Facts and Figures" is now before us, and is no whit behind its predecessors. We need hardly state that the object of the work is to present a register of the progress in mechanical engineering and construction during each year. A leading feature in the present volume is a notice of the International Maritime Exhibition, held at Havre last year, and which was specially visited for the purposes of the work. Some additional notes are given on the Exhibition held in Paris in 1867, which tend to complete the subjects discussed in the previous volume. The matter is, as usual, arranged and classified under distinctive headings. The chief subjects considered are boilers, explosions, furnaces, fuel, steam engines, locomotives, marine engines and machinery in general, metals, railways and ships. Of course there is not room for everything in such a volume; but the selection of matter is admirably made, and the most important points of the various subjects are given, reference being made to the object from which the information is obtained, as a guide to the reader, should he desire farther details. The volume is amply illustrated, and is got up in the usual neat style.—*Mechanic's Magazine.*

LOCOMOTIVE ENGINEERING AND THE MECHANISM OF RAILWAYS: A TREATISE ON THE PRINCIPLES AND CONSTRUCTION OF THE LOCOMOTIVE ENGINE, RAILWAY CARRIAGES AND RAILWAY PLANT. By ZERAH COLBURN, C. E. London and Glasgow: Wm. Collins' Sons & Co. New York: John Wiley, 535 Broadway. 1869.

One of the standing inquiries of students and experts in railway machinery has been, since 1865, "When will the remaining numbers of Colburn's Locomotive Engineering appear?" Nos. 13 and 14 are now before us. The subjects treated are The Link Motion, Combustion, Functions of the Locomotive Boiler and the Principles of the Blast. It is unnecessary to state that these subjects are ably treated. Mr. Colburn has been thoroughly fitted by his long experience as a practical locomotive engineer, and by his training as a student and writer on railway machinery, to handle these subjects in a manner at once thoroughly useful, sound and entertaining. Some of the chapters in these numbers were written by Mr. Ferdinand Kohn, whose work on the Iron and Steel Manufacture is noticed elsewhere. They were, of course, supervised by Mr. Colburn. We shall make further reference to this work as it proceeds.

ANNALES INDUSTRIELLES, PUBLIÉES PAR FREDUREAU, H. DE CHAVANNES ET CIE. A. CASSAGNES, Directeur. Paris, Rue le Peletier.

This is a new French bi-monthly engineering journal. So far this publication promises exceedingly well, and appears to be ably edited. It is, moreover, got up in very good style, each number being illustrated by carefully executed lithographic plates in addition to minor wood cuts interspersed in the text. The plates are of large size, and represent both civil and mechanical engineering subjects.

RAILWAY TRAVELING IN THE NINETEENTH CENTURY, WITH PLAN OF PROPOSED IMPROVEMENTS. By GEORGE LANSDOWN. London: Pettitt & Co., 23 Frith street, Soho. 1869.

This is a pamphlet advocating the American system of passenger cars for British lines.

LAXTON'S BUILDERS' PRICE BOOK FOR 1869, containing about 70,000 prices. London: Morgan & Chase, 1869.

TREATISE ON THE POWER OF WATER AS APPLIED TO DRIVE FLOUR MILLS, AND TO GIVE MOTION TO TURBINES AND OTHER HYDROSTATIC ENGINES. By JOSEPH GLYNN, F. R. S. Third Edition. Revised and Enlarged. New York: D. Van Nostrand. 1869.

It is a pleasure to see an old and valued friend, like this little work by Mr. Glynn, maintaining its well deserved popularity, and reaching a third edition besides an American reprint. The range of subjects treated in this volume is very wide, and almost all the data required in calculations relating to the flow of water; horizontal water wheels; turbines; undershot, overshot and breast wheels; water pressure engines and water rams, &c., are given very fully, and in such a shape that they can be readily used by the practical man. The publishers have certainly laid both students and practical men under deep obligations by this reprint.—*American Journal of Mining.*

THE TRANSACTIONS OF THE SOCIETY OF ENGINEERS FOR 1867. 1 vol. 8vo., with many plates. London: Spon, 1868.

This, the last volume of transactions of this thriving young society, quite maintains the character of its predecessors, and something more, as several of the papers are less of a mere elementary character—having just a little of the smack of schoolboy exercise about them, as was the case with a few of the former ones—and two or three are really able and exhaustive. This is especially true of Mr. Baldwin's paper on "Safety Valves," Mr. V. Pendred on "Tube Boilers," and, above all, Mr. S. W. Worssam on "Mechanical Saws." The volume, like all of the series, is got up in excellent style by the publisher; no clearer or better illustrations need be sought than the lithographs, which equal above a third of the volume in bulk.—*Practical Mechanic's Journal.*

IRON AND STEEL MANUFACTURE: A SERIES OF PAPERS ON THE MANUFACTURE AND PROPERTIES OF IRON AND STEEL; WITH REPORTS ON IRON AND STEEL IN THE PARIS EXHIBITION, ETC., AND DESCRIPTIONS OF MANY OF THE PRINCIPAL IRON AND STEEL WORKS IN GREAT BRITAIN AND ON THE CONTINENT. By FERDINAND KOHN, C. E. London: William Mackenzie, Paternoster-row.

This appears to us, upon cursory examination, to be one of the most complete and useful works extant upon modern iron and steel making. It brings the subject down to the present practice—however long that may last—and is very fully and well illustrated. It is favorably reviewed by the London "Mining Journal," and other professional periodicals. We shall give the work a more extended notice on another occasion. Meanwhile we advise mill managers and thorough students to procure it and review it themselves.

MURRAY'S TREATISE ON THE MARINE ENGINE. Fourth edition. London: Virtue & Co.

This is the treatise as to the publication of which the author, Mr. Murray, has so justly complained in the public papers. It was a good treatise for its time, probably, when first published, but needed much to bring up its leeway. This, the author complains, has been done or attempted by another hand, employed without his knowledge or sanction by the publishers, and whose work the author views as having by no means added to the value of his original. In that we are obliged to agree with the author. The book ought simply to have been reprinted as it stood, or all but rewritten, and not merely padded out by a bulky appendix, of which almost every page has been taken from easily accessible printed documents, &c.

RAILWAY NOTES.

RE-ROLLING OLD RAILWAY IRON.*—The worn-out rails on the Erie and Pennsylvania Railways are re-rolled for further use in the same form, and this process is performed according to the following instructions, which are embodied in the specifications of that company:

1st. The old rails shall be piled in piles, and every piece shall be the whole length of the pile, and the pile so made shall be rolled into flats.

2d. All rails classed as 64 lb. to 67 lb. shall be rolled from a 9 in. rail pile, said pile to be made as follows:

3d. The said flats shall be put into a pile of proper size for a rail, each flat being of the full length of the pile, and of which flats the bar forming top or head of the rail shall be of a new, good, tough, granular re-worked iron, such as will weld well; to be 1¼ in. thick.

4th. The layers forming the central part or stem of the rail shall be of puddled or re-worked iron, of a good quality, or of old rails (at the option of the manufacturer), rolled to a thickness of not over ⅞ in., and of such width that the various layers will break joints, and what is known as a staggered pile formed.

5th. The base of the pile, from which the bottom or flange of the rail is made, shall be of good, re-worked fibrous iron—the under layer of which shall be of full width and length of pile, not less than 1⅞ in. thick. The pile shall be well and carefully heated, so as to insure a good weld.

6th. The short pieces furnished by the railway company, and all short pieces cut off by the rolling mill, shall be piled by themselves, and rolled into a flat, which flat shall either be piled in the rail pile or used in making flanges of the rail. The railway company shall have the right, from time to time, to direct in what part of said pile said flats, so made of the pieces shall be placed; not more than two such flats shall be in any one pile.

7th. The rails to be rolled to pattern furnished by railway company; to be 25 ft. long; not over ten per cent shall be of shorter lengths, but not less than 18 ft.; all rails to be undercut ⅛ in.; to be notched 2¼ in. from each end, the notch to be ¼ in. deep and ⅞ in. long, or of such dimensions as the railway superintendent may direct.

8th. It is mutually agreed that the railway company shall not exact from the iron works rails classed as re-rolled, to be of better material in the central parts and base of the pile than can be produced from the old iron furnished by said railway.

9th. Rails and process of manufacture shall be subject to inspection by such persons as the superintendent of the railway shall select and appoint for that purpose.

MONT CENIS TUNNEL COMPLETION.—According to Italian journals, the completion of the great tunnel is to be the occasion of a great International Exposition at Turin. The Government is to ask Parliament to vote the sum of 3,000,000 francs to cover the expenses of this enterprise. It is expected that the work will be finished in the winter of 1869-70, and that its use will begin early in the latter year. —*Annales du Génie Civil.*

* We copy this from an English paper, but we believe it first appeared in one of our own Journals; we have not the means at hand to give proper credit.

FRENCH RAILWAYS — NEW COMPANY — PARTICULARS OF WORKS.—The larger part of the French railways are worked by five or six large companies; but recently many small local lines have been granted to new companies, who receive subsidies from the local authorities, and are free from many heavy regulations ordered by the Government to the great companies. A new company has thus contracted with the Conseil-général du Department de l'Hérault for 120 miles of new lines from Montpelier to the seaside, from Pezenas to Beziers, and from Montpelier to Lodeve. The company will receive a subsidy of £4,800 per mile. There will be only two classes of carriages, with the fares of the second and third classes of the main lines. The gauge will be the ordinary narrow gauge, the shortest radius of the curves will be 300 feet, and the inclines will not exceed one thirty-third. There will be no fences to the line nor guards to the level crossings, but the speed will not exceed fifteen miles an hour. The weight of the flat bottom rails will be forty-nine pounds per yard, and the average distance of the sleepers will be four feet. The rails are manufactured by the L'Horme Ironworks, near St. Etienne, at £9 15s. per ton. It is intended that the goods wagons of the main line should be admitted on these branches, but the engines will be special tank engines, with four coupled wheels, and weighing sixteen tons, or twelve tons empty. These engines will be supplied by Graffenstaden, near Strasbourg. There will be also some double bogie engines, which are manufactured by the Fives-Lille Company. The carriages, built at Lyons, will have a longitudinal intercommunication; there will be also some two-story carriages for the little line from Montpelier to the seaside, where a large passenger traffic is very probable. These lines will not have large works of engineering except a lattice girder bridge, with five spans of 120 feet each, over the Hérault river.—*The Engineer.*

PROPOSED TUNNEL BETWEEN IRELAND AND SCOTLAND.—A scheme has been proposed for uniting Ireland and Scotland by a submarine tunnel. The entrance to the railway tunnel by which it is to be accomplished on the Irish side is to be from a point about midway between Cusheden and Cushendall, on the coast of Antrim, and on the Scotch side at Glenstrone, from whence it would run through the head of the Mull of Cantyre. The total length of the tunnel under water would be fourteen miles three furlongs, and it is said that the ground through which it would have to be made is exactly suited for tunneling operations, and the sandstone for lining it can be had in any quantity on the Irish side. It is proposed to construct the tunnel for a single line only, the extreme depth being twenty-one feet, and the clear width at the level of the rails fifteen feet. The estimated time that would be occupied in completing the tunnel is, allowing for all contingencies, under six years, and the cost under four and a quarter millions. To pay a dividend of five per cent, the weekly earnings must be forty-two pounds per mile, and an estimate is appended to show that the gross earnings would be largely in excess of this amount, and that the mineral resources of the land in the immediate vicinity of the Irish end of the tunnel would be immensely developed.

PUNCH'S approved method of communication between passenger and guard—a shilling.

THE DELHI RAILWAY, when completed, will establish an unbroken line of railway communication between Calcutta and Lahore, a distance of 1,300 miles. The contract for its construction, for 302¾ miles, was let in 1864. The commencement of the work was, however, delayed until 1865. At the present time the wells for the foundations of the larger bridges have been sunk to the required depth. This railway, besides frequently crossing canals, spans three large and celebrated rivers, the Jumna, the Sutlej, and the Beeas, besides one great mountain stream, the Gugger. The aggregate water-way required for these rivers amounts to upwards of two miles.—On the southern section of the railway, between Umballa and Ghazeeabad, which was formally opened in November, there are eight large bridges, and ten for minor streams, comprising fifteen spans, varying from 60 to 102 ft. in length. On the northern section, seven important bridges are completed. Of materials, 90,000 tons, including permanent way, bridge work, fencing, and plant have been sent from England since the spring of 1865 for the formation of this railway. The date fixed by contract for the completion of the whole line is the third of May, 1870.

SAFETY OF WORKMEN IN TUNNELS.—A new system, affording a great security to the platelayers in the tunnels, is used in the Blaisy tunnel of the Paris and Marseilles line. This tunnel, 13,600 feet long, is sometimes very smoky, and the men had great difficulty in being properly warned of an approaching train. An insulated wire has been laid by the side of the tunnel five feet over the ground. The ganger of the platelayers is supplied with a portable electric bell that he must suspend to the wire in the neighborhood of the place where his men and himself are working. The electric communication is completed by an iron wedge inserted between two rails of the line, and connected by a wire to the electric bell. As soon as a train goes into the tunnel, the signalman of the clock system at the entrance of the tunnel sends an electric current in the wire and rings the bell continually until the signal "line clear" is received from the other end of the tunnel.—*The Engineer.*

ALTITUDES.—The highest point on the Central Pacific Railroad is in the summit of the Sierra Nevada, it being 7,042 feet above the level of the sea, and the next highest is Pepoup Pass, 6,180 feet above the level of the ocean, and 541 miles east of Sacramento, in the Goose creek range of mountains. The highest points on the Union Pacific are Green river, 6,145 feet above the level of the sea; Benton, 6,635; Laramie, 7,175; Sherman, 8,424; and Cheyenne, 7,040.

PEAT FOR LOCOMOTIVE FUEL.—The following results have been obtained on the Grand Trunk railroad in Canada: Number of miles run by train, 683; aggregate distance run by all the cars, 15,267; average number of cars per train, 22.4; peat consumed, 48,745 pounds; wood for same work, 105,187 pounds; number of miles run per ton of peat, 31.6; number of miles run per cord of maple wood, 27.6; experiment in favor of peat, 14 per cent.

A RAILWAY IN PERSIA, from Teheran to a suburb 6 miles out, is in progress.

RAILWAY TIME TABLES IN HOLLAND.—We find in the Dutch journal "Opmerker" the following lines:

"*Bois-le-Duc.*—The provincial Court of Appeals has just given its decision upon a writ of error, from the tribunal of Breda, in the case of M. J. Urban, residing at Brussels. The tribunal found M. Urban guilty of a violation of the law of Aug. 21st, 1859, containing provisions for the management of railways, in failing to cause the departure of the Rozendaal train at the time indicated in the tables on the evening of Sept. 29th. M. Urban was fined 200 florins, and sentenced besides to six days in jail.

"The Court of Appeals has confirmed the judgment, and the appellent has been compelled to pay the costs."

M. J. Urban, we believe, is the director-general of the Grand Central Railway of Belgium, which has a station at Rozendaal. It seems that the Dutch Government requires railway time tables to be kept up to. Nobody will blame it in this case. —*Annales du Génie Civil.*

ABANDONMENT OF BROAD GAUGE.—The northern section of the Great Western Railway of England is now worked entirely upon the narrow (4 ft. 8½ in.) gauge. The 7 ft. gauge is being gradually abandoned on the entire line.

RAILWAYS IN PERSIA—The Shah of Persia has recently granted to English capitalists the monopoly of railroad building in that county for twenty years.

A CAR is now building in Jersey City, which will be the costliest, the largest and one of the most elegant in the world. It is for the Erie road, and will cost $60,000.

MISCELLANEOUS.

NOTICE TO OUR COTEMPORARIES.—Several technical journals are in the habit of copying without credit from "Van Nostrand's Magazine" translations from French and German magazines. We do not quite see the propriety of copying without credit our abstracts of papers and articles from the English journals; but when we have undertaken the expense and trouble of translating as well as compiling, we think an acknowledgment thereof, on the part of our said cotemporaries, would be at once just and polite.

NEW BOOKS.—It may perhaps be unnecessary to call the attention of our readers to the series of notices under this heading. This is probably the most comprehensive list of new professional books that is accessible to the general reader; and the notices present not only sufficient specifications of the subjects treated, but the average professional opinion as to the manner in which they are treated.

A NEW ALLOY.—A new alloy, forming, we are told, a beautiful white metal, very hard, and capable of taking a brilliant polish, is obtained by melting together about 70 parts of copper, 20 of nickel, 5¼ of zinc, and 4¼ of cadmium. It is, therefore, a kind of German silver, in which part of the zinc is replaced by cadmium. This alloy has been recently made in Paris for the manufacture of spoons and forks, which resemble articles of silver.

WOODEN PAVEMENTS IN CALIFORNIA.—Not content with giving a fair trial to the widely-known Nicholson wood pavement, the Californians have devised several kinds of their own, two of which, known respectively as the Perry and the Stow pavements, have been tested to some extent in the streets of San Francisco. The Perry method consists in having the blocks sawed in such shape that when laid down they will occupy a position in which the grain of the wood, instead of being vertical, will lie in an inclined position, with V-shaped grooves or recesses arranged between their upper portions, and filled with gravel unmixed with asphaltum, or other waterproof or binding substance, this last being considered unnecessary. The grooves or recesses are caused to break joints, and are, of course, designed to facilitate the foothold of horses, &c., passing over the pavement. It is claimed that by this plan of laying the blocks the latter are caused to mutually sustain each other, that their surfaces are less subject to being battered and abraded by iron-shod hoofs and the tyres of wagon wheels, and that the expansion of the blocks consequent on the absorption of moisture, instead of causing the pavement to "arch," will simply make each block slide slightly upon the inclined surface of its neighbor. The blocks employed in the experiments thus far made with this kind of pavement, have been subjected to a preservative process, in which the pores of the wood are filled with sulphates of lime and iron. The Stow pavement resembles the Nicholson in the shape and size of its blocks; but instead of the plank foundation of the latter has provided underneath it a bed of sand. The sand is densely packed to support the blocks, and also the superincumbent pressure of travel thereon, by means of longitudinal rows of wedges driven down into the sand alternately with the several series of block. The great advantage of this system lies in the facility with which it may be taken up and replaced when desired, as, for instance, in the case of sewage repairs, &c. Akin to the subject of pavements is that of sidewalks, and in the construction of these asphaltum appears to be coming into very extended use in the Golden State. In San Francisco they are made as follows: Upon the sand is laid a foundation of boards, upon this is placed a layer of brick, and upon the brick is spread a cement which is constituted by asphaltum from Santa Barbara, mixed with ordinary gravel of fine texture.—*Engineering.*

SPECIMENS OF LARGE BELTS.—Messrs. Hoyt Brothers, of New York city, have lately finished two very large belts, a portion of an order for the American Print Works of Fall River, Mass. One is 228 feet long and 38 inches wide, double; the other 107 feet long by 36 inches wide, also double, each about five-eighths of an inch in thickness. Weight of the larger belt 1,998 lbs., and of the smaller one 810 lbs. One hundred and fifty of the choicest "buts" were selected from 3,000 hides, themselves sorted from about 9,000. The leather of these belts is wholly from domestic cattle, and tanned with oak bark only, at the tannery of the company in Cumberland, Md., no extraneous acids or hot liquors being used. At first price the value of the largest belt would amount to over $2,800. The material and workmanship are certainly creditable to the manufacturers.—*Scientific American.*

The experiment of making belting from paper has proved a success in the hands of Crane & Co., at Dalton, Massachusetts, and the article is now used in all their own mills and several other manufacturing establishments. The belting resembles the genuine oak-tanned leather, and serves alike well in a dry or damp atmosphere.—*Engineer.*

THE LATE OCEAN STEAMSHIP RACE.—The City of Paris (Inman line) steamed from New York to Queenstown in 9 days 7 hours 23 minutes; stopped at Queenstown 20 minutes; steamed from Queenstown to Liverpool in 18 hours 27 minutes; total run, 10 days 2 hours 10 minutes.

The Russia (Cunard line) steamed from New York to Queenstown in 9 days 8 hours 5 minutes; stopped at Queenstown 23 minutes; steamed from Queenstown to Liverpool in 17 hours 12 minutes; total run, 10 days 1 hour 40 minutes.

The City of Paris won the race to Queenstown, beating the Russia by 42 minutes only. The Russia won from Queenstown to Liverpool, beating the City of Paris by 75 minutes, to which add 3 minutes longer stoppage at Queenstown; the Russia recovering her lost way, and winning by 33 minutes on the total distance steamed, which by the Russia's log was 3,066 miles in 10 days 1 hour 17 minutes, or about 12¾ miles per hour whilst under way in steaming.—*Cor. Engineer.*

A NEW SUBMARINE LIGHT.—An interesting experiment was recently made at the residence of Dr. Doremus, in New York city, in order to test the utility of a new method of illumination under water, invented by a lady—Mrs. Devoe—and designed to facilitate the various operations of submarine engineering. The plan, which has been patented by the inventor, or rather the "inventress," is simply this: Two rows of convex glasses are arranged in the side of a vessel below the water-line, and suitable lights—magnesium, calcium, or electric—are so arranged in relation with the glasses and with appropriate reflectors that the rays are thrown out into the water to illuminate the same. It is intende to use in conjunction with this apparatus a peculiarly constructed device by which objects in the water will be reflected upon a submerged mirror in such a way that the images may be perceived on looking down the tube or body of the instrument, which resembles that of an ordinary telescope.—*American Artisan.*

PREVENTIVE FOR "DRY ROT."—Builders, allotment gardeners, and others who employ home grown timber for fencing and other purposes, will be glad to hear that an effectual preventive for the "dry rot" has been discovered. The recipe is forwarded to the "Gardeners' Chronicle" by Mr. J. Baily Denton, and has been thoroughly tested by experiment. It consists in soaking the timber for a short time in lime-water. A pit or tank, or good-sized barrel, according to the extent of requirement, will answer the purpose, the lime being added to the water in the proportion of eighty-eight grains to one gallon. Timber creosoted in this way stands the weather remarkably well, and is not subject to the decay to which unprepared timber is so liable.

A NEW LIGHT.—Mr. James Allison Hogg, gas engineer, Edinburgh, has discovered a method of producing intense light with coal gas by mixing it with atmospheric air. The mixture of gases is lighted after passing through a tissue of iridio-platina wire at a determined pressure. In a few seconds the metal becomes heated up to a white heat, the flame disappears, and an intense white light is the result. An enlarged picture has been taken by its aid on prepared photographic paper. The light will burn in a gale of wind without any protection round it, and a downpour of rain will not affect it.

PRESERVING TIMBER.—Dr. L. Feuchtwaner's process for the preservation of timber is simply to steam the timber, and then inject a solution of silicate of soda for eight hours, after which the wood is soaked for the same period in lime-water.—*Engineer.*